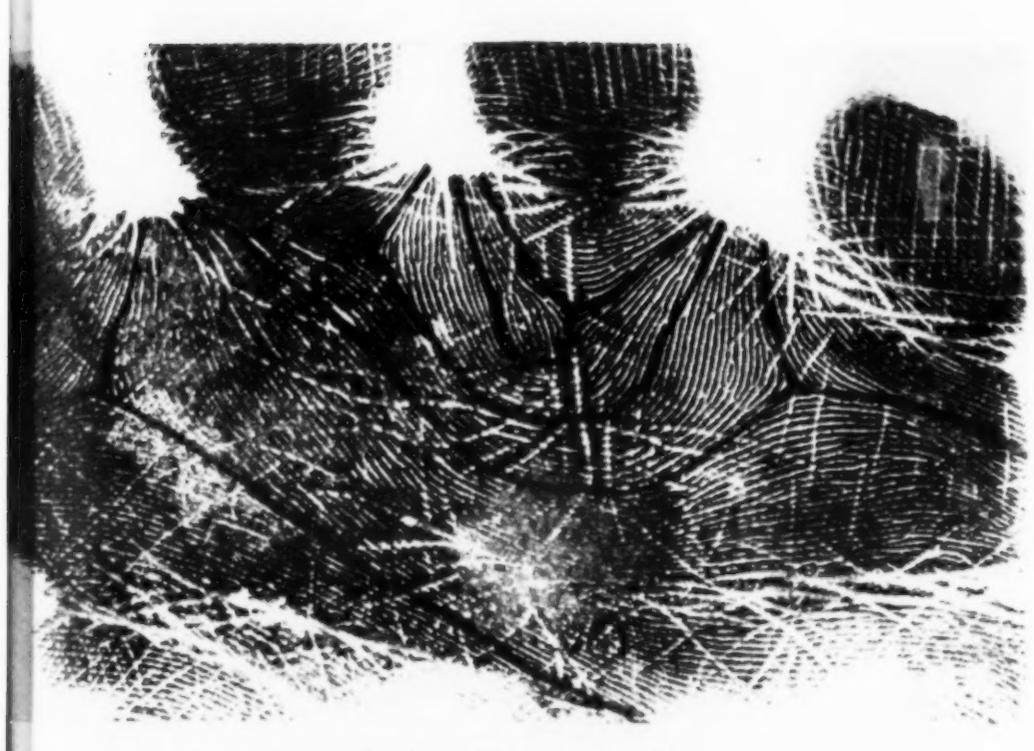
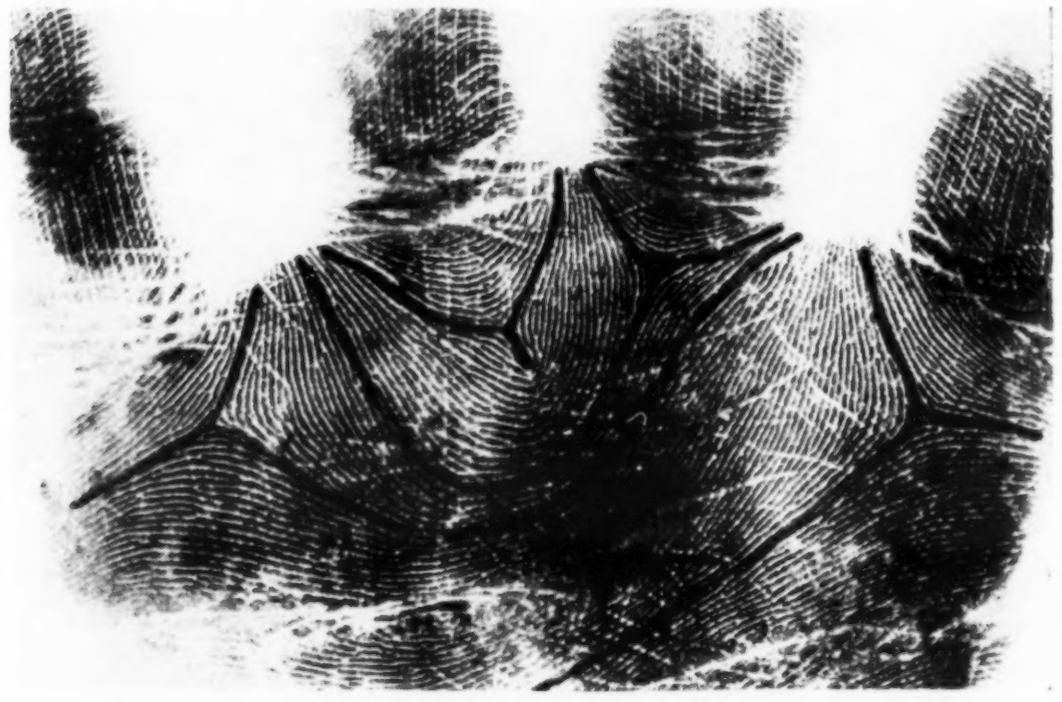
PERIODICAL ROOM
GENERAL LIBRARY
UNIV. OF MICH.

MAR 7 1929

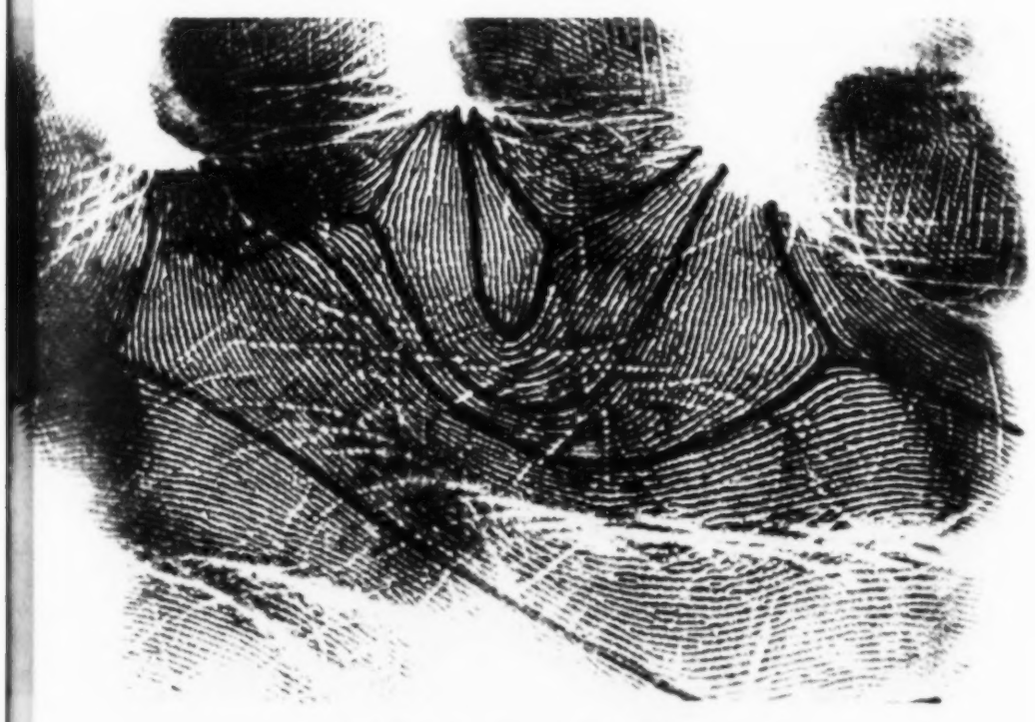
# The Journal of HEREDITY



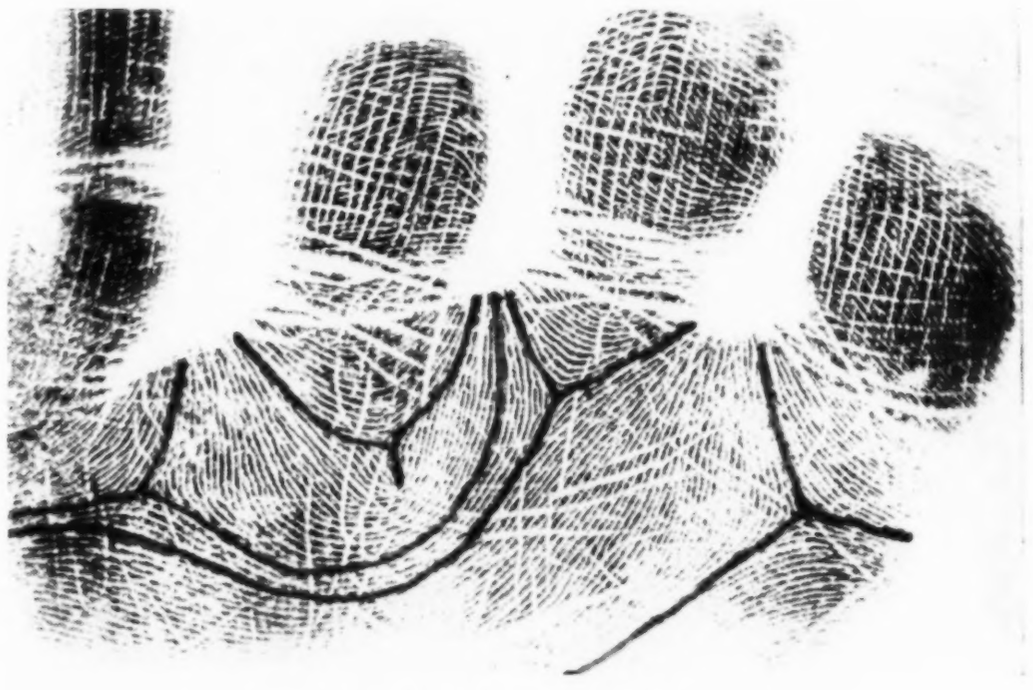
Right Palm of "O"



Left Palm of "A"



Right Palm of "A"



Left Palm of "O"

PALM-PRINTS OF IDENTICAL TWINS

*Recessive Extra Fingers* — *Industrial Peasants*

*Mongolism in Twins* — *Yellow Fatuoid Oats*

*Nurse-Graft Propagation of Orange*

*Darwin's Home a Memorial*

VOLUME 20 FEBRUARY, 1929 NUMBER 2

# The American Genetic Association

***An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks***


DAVID FAIRCHILD, President — Vice-President, W. E. CASTLE — Secretary, C. E. LEIGHTY

Treasurer, MRS. G. W. SINCELL

JOHN B. LARNER, Financial Advisor — Legal Advisors, PEELLE, OGILBY and LESH

## EDITORIAL BOARD

M. DEMEREC — R. R. GRAVES — L. C. DUNN

H. J. MULLER — GEORGE M. DARROW — PAUL POPENOE

Members of the Council are ex-officio members of the Editorial Board

Managing Editor: ROBERT C. COOK

## COUNCIL

W. E. CASTLE, Professor of Zoology, Harvard University, and Research Associate of the Carnegie Institution of Washington.

LEON J. COLE, Professor of Genetics, University of Wisconsin.

G. N. COLLINS, Botanist, U. S. Department of Agriculture, Washington, D. C.

O. F. COOK, Bionomist in Charge of Breeding Investigations, U. S. Department of Agriculture.

DAVID FAIRCHILD, Agricultural Explorer, U. S. Department of Agriculture.

HARRY V. HARLAN, Senior Agronomist in Charge of Barley Investigations, U. S. Department of Agriculture.

C. E. LEIGHTY, Agronomist in Charge of Eastern Wheat Investigations, U. S. Department of Agriculture.

VERNON KELLOGG, Chairman, Division of Educational Relations, National Research Council, Washington, D. C.

J. H. KEMPTON, Bureau of Plant Industry, U. S. Department of Agriculture.

E. W. SHEETS, Chief of Animal Husbandry Division, U. S. Department of Agriculture.

FREDERICK ADAMS WOODS, Lecturer on Biology, Massachusetts Institute of Technology.

SEWALL WRIGHT, Associate Professor of Zoology, University of Chicago.

## ADVISORY COMMITTEE

W. S. ANDERSON, Genetics Department, University of Kentucky, Lexington, Kentucky.

E. B. BABCOCK, Genetics Department, University of California, Berkeley, California.

E. A. BESSEY, Professor of Botany, Michigan State College, East Lansing, Michigan.

A. F. BLAKESLEE, Plant Genetist, Carnegie Institution, Cold Spring Harbor, New York.

J. K. BREITENBECHER, McGill University, Montreal, Canada.

W. E. BRYAN, Professor of Plant Breeding, University of Arizona, Tucson, Arizona.

C. B. DAVENPORT, Director, Department of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, L. I., New York.

J. A. DETLEFSEN, Professor of Genetics, Wistar Institute, Philadelphia, Pennsylvania.

RUSSELL W. DUCK, Professor of Animal Husbandry, Syracuse University, Syracuse, New York.

E. M. EAST, Professor of Plant Genetics, Bussey Inst. of Applied Biology, Boston, Mass.

R. A. EMERSON, Professor of Plant Breeding, Cornell University, Ithaca, New York.

C. P. GILLETTE, President, The Genetic Foundation, Fort Collins, Colorado.

C. M. GOETHE, Sacramento, California.

FREDERICK O. GROVER, Professor of Botany, Oberlin College, Oberlin, Ohio.

ROBERT T. HANCE, Zoology Department, University of Pittsburgh, Pittsburgh, Pa.

HARRISON R. HUNT, Professor of Biology, Michigan Agricultural College, East Lansing.

R. E. HUNT, Professor of Animal Husbandry, Virginia Polytechnic Institute, Blacksburg, Va.

H. S. JENNINGS, Professor of Zoology, Johns Hopkins University, Baltimore, Maryland.

D. F. JONES, Plant Breeder, Connecticut Agricultural Experiment Station, New Haven, Conn.

F. B. LINFIELD, Director, Montana Experiment Station, Bozeman, Montana.

WM. A. LIPPINCOTT, Professor of Poultry Husbandry, University of California, Berkeley, Cal.

C. C. LITTLE, President, University of Michigan, Ann Arbor, Michigan.

JAY L. LUSH, Animal Husbandman, Texas Agricultural Experiment Station, College Station.

H. H. NEWMAN, Professor of Zoology, University of Chicago, Chicago, Ill.

T. S. PALMER, Expert in Game Conservation, U. S. Dept. of Agriculture, Washington, D. C.

JOHN H. PARKER, Professor of Agronomy, Kansas State College, Manhatten, Kansas.

MRS. CHARLES C. RUMSEY, Wheatly Hills, Westbury, Long Island.

JOHN M. SCOTT, Vice Director, Florida Agricultural Experiment Station, Gainesville, Florida.

JOHN W. SCOTT, Professor of Zoology, University of Wyoming, Laramie, Wyoming.

A. D. SHAMEL, Pomologist, U. S. Department of Agriculture, Riverside, California.

GEORGE H. SHULL, Professor of Biology, Princeton University, Princeton, New Jersey.

W. W. SMITH, Professor of Animal Husbandry, Purdue University, Lafayette, Indiana.

CHARLES R. STOCKARD, Professor of Anatomy, Cornell University, New York City.

A. B. STOUT, Director of Laboratories, New York Botanical Gardens, New York City.

W. T. SWINGLE, Plant Physiologist in Charge of Breeding Investigations, U. S. Department of Agriculture, Washington, D. C.

LOU D. SWEET, Seedsman, Denver, Colorado.

W. H. TOMHAVE, American Aberdeen-Angus Breeders' Association, Chicago, Ill

H. E. WALTER, Professor of Biology, Brown University, Providence, Rhode Island.

H. J. WEBBER, Director, Citrus Experiment Station, Riverside, California.

E. N. WENTWORTH, Armour's Bureau of Agr'l Research and Economics, Chicago, Illinois.

P. W. WHITING, Department of Biology, University of Pittsburgh, Pittsburgh, Pa.

*The*

# Journal of Heredity

Vol. XX FEBRUARY, 1929 No. II

## IN THIS ISSUE

MENTAL AND PHYSICAL TRAITS OF IDENTICAL TWINS REARED APART
*By H. H. Newman* ..... 49

YELLOW-KERNELED FATUOID OATS
*By T. R. Stanton and F. A. Coffman* ..... 67

STUDIES IN HUMAN INHERITANCE
*By Laurence H. Snyder* ..... 73

THE NURSE-GRAFTED Y-CUTTING METHOD OF PLANT PROPAGATION
*By Walter T. Swingle, T. Ralph Robinson, Eugene May* ..... 79

MONGOLISM IN TWINS ..... 64

DARWIN'S HOME A MEMORIAL ..... 72

INDUSTRIAL PEASANTS ..... 70

H. G. WELLS ON EUGENICS ..... 77

BOOKS RECEIVED ..... 94

## COMING

### *E. D. Metcalf*

**Sailor, Artisan, Justice of the Peace, Merchant, Stockman, Believer in Heredity.**

### *Leg-Feathering in Fowls*

**The genetics of a character that causes no little trouble to the poultry breeder for "points."**

### *Twin and Triplet Birth Ratios*

**Peculiar numerical relations exist between the ratios of single births, twins and triplets. What is the biological explanation?**

### *Multiple Kernels in Wheat-Rye Hybrids*

**Twin- and triple-grained tendencies in a genus cross.**

The JOURNAL OF HEREDITY is published monthly by the AMERICAN GENETIC ASSOCIATION, at 1918-32 Harford Avenue, Baltimore, Md., and Victor Building, Washington, D. C. Address all communications regarding editorial matters and the business management of the Association to Room 306, Victor Building, Washington, D. C. Entered as second-class matter February 24, 1923, at the postoffice at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1927, authorized December 20, 1918. Contents copyrighted 1929 by the American Genetic Association. Reproduction of articles or parts of articles only upon request, for a proper purpose, and provided due credit is given to the author and to the JOURNAL OF HEREDITY, Washington, D. C.

***$3.50 a Year*** *Prices of back numbers on application* ***35c. the Copy***

"A" "O"

**TWINS SEPARATED SEVENTEEN YEARS**

**Frontispiece**

Born in the Chelsea District of London and separated at the age of eighteen months, "A" lived on in London while "O" was raised in a small Canadian city. The twins are unquestionably identical, so that the similarities and differences revealed by this study represent important new data in the much debated question of the relative importance of heredity and environment in the mental development of the individual.

MH

S

attra
entit
had
logic
twin
Mul
kind
desi
mad
is v
has
thes
are
acco
ler,
our
data

C
data
dev
the
as
writ
new
twi
valu
rese

C
fer
to
tha
kin
the
see
the
eig
dea
mo
chi
tri

ther

# MENTAL AND PHYSICAL TRAITS OF IDENTICAL TWINS REARED APART

## Case I. Twins "A" and "O"

H. H. NEWMAN
*University of Chicago*

SOMEWHAT over two years ago there appeared in this journal a paper by H. J. Muller that attracted wide attention. This paper entitled "Mental Traits and Heredity" had as its basis a genetic and psychological study of a pair of identical twins reared apart. The fact that Muller's paper is the only one of the kind in the literature makes it highly desirable that other similar studies be made. At the present time the writer is working upon five such cases and has completed the study of three of these. The findings and conclusions are in several respects quite out of accord with those presented by Muller, a fact which lends importance to our effort to get a larger amount of data before attempting to generalize.

On account of the rather voluminous data involved, this first paper will be devoted entirely to the first case in the group now being studied. This, as well as other cases, came to the writer's attention as the result of a newspaper story about our work on twins, a fact which emphasizes the value of publicity in this kind of research.

One of the twins, who will be referred to as "O" in the paper, wrote to the writer expressing the opinion that she and her twin sister were the kind of twins desired and offering themselves for study. The case seemed especially interesting because the twins were separated at the age of eighteen months as the result of the death of the mother. The father and mother were both English and the children were born in the Chelsea district of London. As babies they were very much alike. "O" was adopted by relatives and "A" by friends of the family. The foster parents of "O" moved to Ontario, Canada, when "O" was a little over two years old. The other twin, "A," lived on in Chelsea until the death of her foster parents and then joined "O" in Ontario. The period of separation, except for one short visit at the age of ten, lasted for about seventeen years. They had been together for about a year when we studied them, thus giving the English twin a good chance to become adjusted to the new situation.

The home environment of "O", as judged by the comments of the twins and of the foster parents, was considerably more favorable; the schooling of the twins was the same in amount, as nearly as we can judge; and they were both given the same kind of training for business life, each taking a two years' commercial course. The difference, from the standpoint of environment, between a crowded section of London and a relatively small Ontario town is very great. In London the social stratification is well defined; in the colonial town everyone is on much the same level socially. In London the war period caused much privation and malnutrition, a condition never evident in Ontario. In brief, the two environments were as different as one is likely ever to find in cases of separated identical twins. If environmental differences are effective in shaping mental and emotional characters they should have been effective in this case. But discussion of the data at this point would be premature. Suffice it to say that this case seems

"A" "O"

**THE SAME—BUT DIFFERENT**

**Figure 1**

"A" and "O" are unquestionably identical twins and the differences are rather emphasized by their extreme similarity. Identical twins reared together often show a certain dissimilarity, due perhaps to the asymmetry mechanism of development that produces quite considerable variation in the two sides of the same face. This, rather than the environment may have been a factor in producing the difference in expression.

to h
scier

**A**

O
futil
are
there
mere
no
their
first
of t

F
tion
K.
Mite
in a
of
Ove
twir
tech
clas
cate
frat
with
plac
In
that
are
alm
out
any
twi
sig
pair
of
gre
nor
in
(st
(co
diff
sta
ex
cla
Th
ass
fid
lab
two
ter

to have all the earmarks of the ideal scientific experiment.

### Are These Twins Monozygotic?

Of course this whole study would be futile unless we can be sure the twins are one-egg, or "identical", twins. If there were any chance of their being merely two-egg twins ("fraternals") no conclusions could be based upon their resemblances or differences. Our first task then is to examine the claims of these twins to rank as identicals.

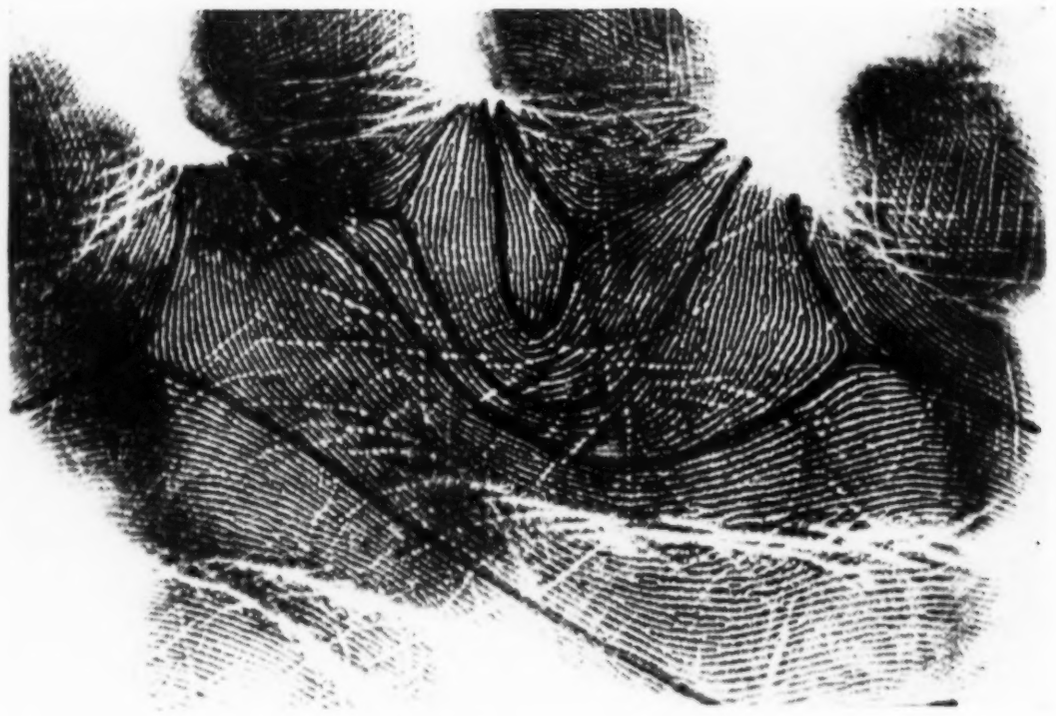
For the last two years (in collaboration with Professors F. N. Freeman, K. J. Holzinger, and Mrs. Blythe Mitchell) the writer has been engaged in an intensive study of human twins of primary and secondary school age. Over a hundred pairs of same-sexed twins have been studied in detail and a technique has been developed for classifying such twins into the two categories, identical (monozygotic) and fraternal (dizygotic), which enables us with nearly complete confidence to place all cases in one or other group. In the first place, it should be said that at least 90 per cent. of all cases are unequivocal and may be classified almost at a glance. Only six cases out of one hundred and two caused any real difficulty. These six pairs of twins consist of three pairs now assigned to the identical group and three pairs to the fraternal group. In all of these cases the resemblances are great, but by no means perfect. In none are there any marked differences in skin color, hair color, hair form (straight, wavy, curly), hair texture (coarse, fine), eye color; but there are differences of various degrees in stature, weight, ear-shape, dentition, expression, etc. How then can we classify this small anomalous group? Three of the six pairs were originally assigned, with varying degrees of confidence on the part of the four collaborators, to the "identical" group, two were classed as very similar fraternals, and one was very doubtful.

A study, especially of the palm and finger prints and of asymmetrical features (ears, dentition, shape of mouth) showed that a great majority of the uniquivocal cases of identical twins exhibit same-sided asymmetry, the right side of one twin being more like the right side of the other twin than like his own left side. Also, usually the left side of one is more like the left side of the other than like his own right side. This rule holds true especially in the most strikingly similar twins. In the less strikingly similar, yet unequivocal cases of identical twins, the right side may be like the right, but the left side may not be any more like the left than like his own right side. In still other cases of certain identicals, especially in those pairs in which one twin is left-handed, the left hand of one twin is more like the right hand of the other twin than like his own right hand. In brief, when one considers palm main-line arrangement, the occurrence of special patterns in the palm, the presence of whorls, loops and arches in the various fingers, and the texture of the friction ridges, the rule holds that *in all unequivocal cases of identical twins there is stronger cross resemblance between twins than resemblance between the two sides of the same twin.* This being the case, when strong cross resemblance is found in the pairs of twins that are strikingly similar, but not obviously identical, this is considered as definitely deciding evidence of their monozygotic origin. When, on the other hand, there is in twins of the doubtful sort no such cross resemblance, the decision must be that they are dizygotic.

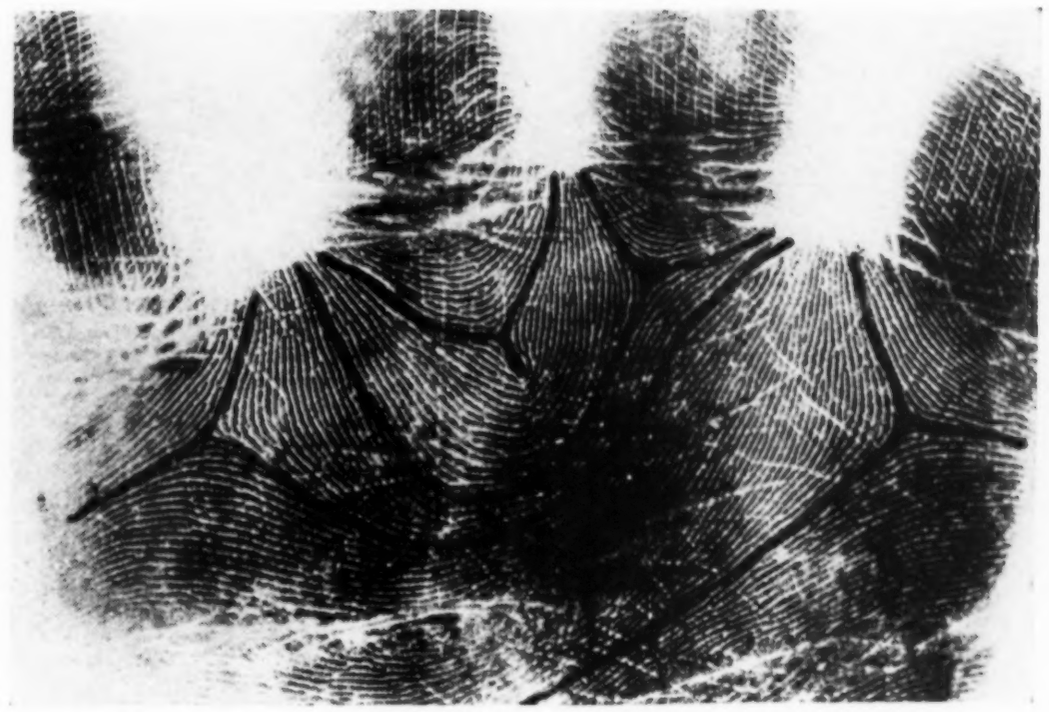
Making use of these criteria, our six slightly questionable cases fell readily into the two categories, three showing evidence of being monozygotic and three showing no such evidences.

The twins that are the subject of our present study are not of the most strikingly identical sort, nor are they of the really doubtful sort: they are about median between the most strik-

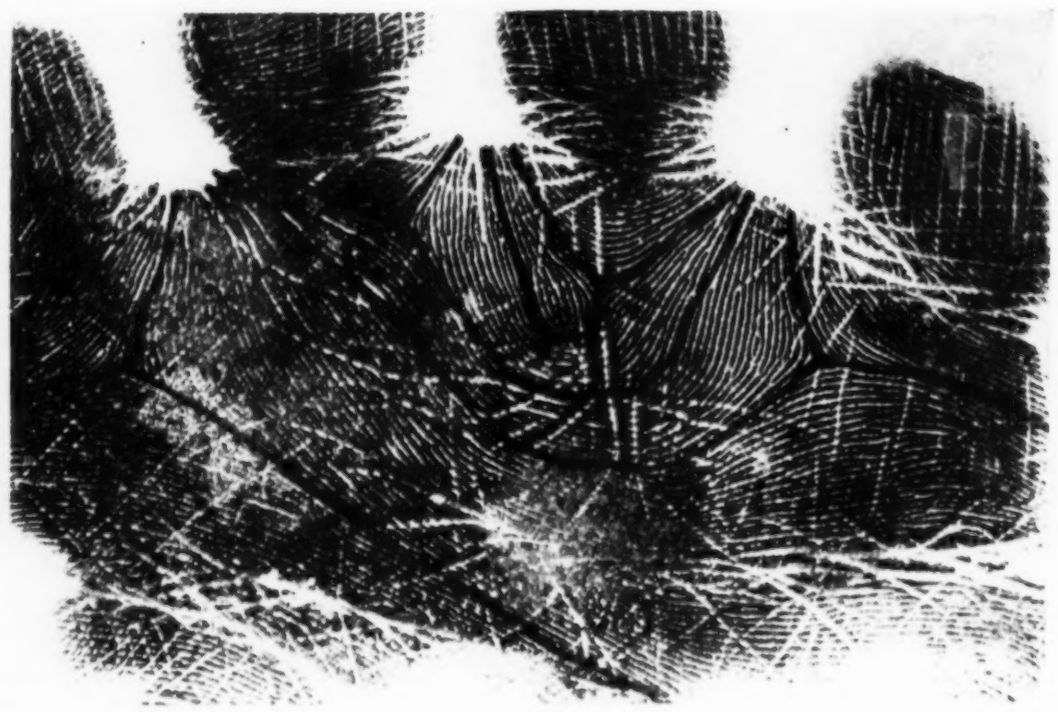
factor in producing the difference in expression.



Right Palm of "A"



Left Palm of "A"



Right Palm of "O"

Left Palm of "O"

**PALM MAIN LINE PATTERNS OF THE TWINS**

**Figure 2**

The two rights and the two lefts resemble each other more closely than they resemble their respective other hands. This is almost conclusive evidence that the twins are identical.

ingly similar and the least similar identical twins of our large collection. They show in finger prints and palm prints very strong and positive cross-resemblance.

### Finger Patterns

A study of the finger prints shows that the two left hands have the same formula, an extremely rare one, unlike any other in our whole collection:

*Left-hands*

| *Digits* | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| "A" = | U. | R. | R. | U. | U. |
| "O" = | U. | R. | R. | U. | U. |

*Right-hands*

| *Digits* | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| "A" = | U. | U. | U. | U. | U. |
| "O" = | U. | R. | A. | U. | U. |

Nineteen of the twenty fingers show loops, some very much reduced, and one is an arch. While radial loops (R) are quite common on digit 2, they are extremely rare on digit 3. In the two left palms the presence of radial loops on digits 2 and 3 of both twins is an extraordinary correspondence and in itself is almost conclusive evidence of monozygotic origin. The right fingers of the twins are less similar, a condition usual for the less strikingly similar "identical" twins.

The quantitative values of the finger patterns, as based on counts of the ridges from triradius to center of loop, counting every ridge in every finger and totaling the five fingers of each hand, are as follows:

"A": Right-hand, 32: Left-hand, 39: Total, 71
"O": Right-hand, 40: Left-hand, 31: Total, 71

Two remarkable situations are revealed here: first, that the right hand of each is more like the left hand of the other than like own left, and that the total of the two hands adds up to exactly 71 ridges in both twins. This is an unusual correspondence and was never even closely approached by any but the most closely similar identical twins in our collection. Here is another correspondence which, almost alone, would be a sufficient criterion of monozygotic origin, for it compares more than favorably with the closeness of correlation found in connection with the numbers of scutes in the bands of the monozygotic quadruplets of the nine-banded armadillo. The reversal of asymmetry (right hand like left) is significant in view of the fact that twin "A" is naturally left-handed.

### The Palm Patterns

The palm main-line formulae, following the latest unpublished method and notation of Cummings, Midlo, Montgomery, H. H. Wilder and I. W. Wilder, read as follows:

"A": L = (11. x.7.3) A. O. O. O. O.
R = (11. 9.7.3) A. O. O. L. O.
"O": L = ( 9. x.5.5) A. O. O. O. O.
R = (11. 9.7.3) A. O. O. L. O.

To the specialist in palmatoglyphics this would be full of meaning, but the general reader will get more out of the study of the palm prints themselves (Figure 2). Mrs. Blythe Mitchell, who took the prints, experienced considerable difficulty in getting prints of the whole palm that showed the entire pattern, but she made numerous prints that are excellent for study and comparison, though less suitable for reproduction. The prints of the most important parts of the four palms are very clear and bring out the strong resemblance of right hand to right, and left hand to left. Especially striking in their resemblance are the two right palms. In these the course of main line C (starting at the base of the fourth finger) turns back in a radial direction to form a short, narrow loop of unusual type. In the two left hands, the corresponding main line (C) ends abruptly close to the triradius, a relatively rare condition designated as X. The real difference in the two left palms appears in the reverse relation of main lines A and B with reference to each other. In "A's" left palm, line A runs proximal to line B and ends in position 11; while in "O's" left palm, line A runs distal to line B and ends in position 9. The patterns of the two left hands present,

TABLE I—Showing Resemblances and Differences in Parents and Sibs

| | Height | Body build | Eye color | Skin color | Hair color | Hair shape | Nose |
|---|---|---|---|---|---|---|---|
| Twin "A" | below med. | slight | hazel brown | medium | reddish brown | nearly straight | long, straight |
| Twin "O" | below med. | slight | hazel brown | medium | reddish brown | nearly straight | long, straight |
| Father | medium | slight in youth | hazel brown | dark | brown | wavy | long, thin, straight |
| Mother | tall | slender | blue | very fair | very light | wavy | long, thin |
| Brother W. | above med. | medium | blue | fair | light | very curly | thinner than twins |
| Brother H. | above med. | medium | brown | dark | very dark | kinky | like Bro. W. |
| Brother J. | above med. | heavy | gray blue | fair | dark brown | straight | straight, but wider than twins |
| Sister E. | ? | ? | ? | fair | light | ? | died at 1 yr. |
| Brother F. | above med. | slight | light brown | dark | light brown | nearly straight | same as twins |
| Sister I. | ? | ? | ? | dark | dark | ? | ? |
| Sister L. | medium | medium | bright blue | light | medium brown | straight | straight like W's |

TABLE II--Physical Measurements

| | "A" | "O" |
|---|---|---|
| Standing height | 5' $1\frac{5}{8}$" | 5' $1\frac{3}{4}$" |
| Sitting height | 2' $9\frac{1}{4}$" | 2' $8\frac{5}{8}$" |
| Weight now | $92\frac{1}{8}$ lb. | 102 lb. |
| Maximum weight | 104 lb. at 16 yrs. age | 115 lb. at 12 yrs. age. |
| Chest | $30\frac{1}{2}$" | 31" |
| Waist | $23\frac{1}{4}$" | $25\frac{1}{4}$" |
| Hips | $32\frac{1}{8}$" | $32\frac{1}{4}$" |
| Thigh | $17\frac{3}{4}$" | $19\frac{1}{4}$" |
| Ankle | 9" | $9\frac{1}{8}$" |
| Finger height | $23\frac{3}{4}$" | $23\frac{1}{2}$" |
| Arm Stretch | $60\frac{1}{8}$" | $61\frac{1}{2}$" |
| Neck | $11\frac{1}{2}$" | $12\frac{1}{4}$" |
| Wrist | $5\frac{1}{8}$" | $5\frac{1}{8}$" |
| Glove size | $6\frac{1}{2}$ | $6\frac{1}{2}$ |
| Shoe size | 4 | $4\frac{1}{2}$ |
| Head length | 17.5 | 17.9 |
| Head width | 13.6 | 13.8 |
| Cephalic index | .777 | .771 |

however, a striking similarity and are much more alike than they are like corresponding right-hand patterns.

In addition to the main line formulae given above, there appear also formulae indicating the presence of palm patterns. Without going into a detailed discussion of palmatoglyphics, it may be said that all four palms show the relatively rare hypothenar pattern (that pattern on the "heel" of the palm). In twin "A" this pattern is in the form of an oval loop opening toward the center of the palm, and it is well developed in both palms. In twin "O" this pattern is clearly indicated by the contours of the lines, but is not a complete loop in either hand. No other patterns appear except the fourth interdigital in both right hands, where it is evident within each of the small loops referred to above. Thus it appears that in this one respect, the presence of hypothenar patterns, both hands of "A" are more alike than like either hand of "O", but that in all other respects one hand of one twin is more like one hand of the other twin than like her own other hand. In brief, the palms of these twins, if they were included in our large series, would rank fairly high among those of the first grade identical twins.

### Evidence Derived by Comparing with Sibs

If more proof be needed that our twins are monozygotic, we are fortunately able to supply the kind of proof furnished by Muller, based on a comparison of the twins with their brothers and sisters. While Muller had only partial information about three sibs, we have full information about five and partial information about two others. The characters of the father and mother are also known. The following table (Table 1) gives these data.

It will be seen that the father and mother were very different in hair, eyes, complexion, and somewhat different in stature and build. From such a mating one would expect a highly variable assortment of progeny; and this is just what the table shows. No two of the sibs, except the twins, are at all alike. While one may be like another in one or two respects there are differences in several others. In contrast with this, the twins are alike in all respects dealt with in this table as also in a long list of other characters listed in Table II.

A reference to Table A in the appendix of Muller's paper will show that there were records of individual differences for only three sibs of twins and that a good many of the items are missing. In spite of this, Muller calculates, by a method which he has ably defended as to its soundness, that there is only one chance in 386 that his twins are different in genetic composition. In other words, the chances are 385 out of 386 that they are identical, or monozygotic, twins.

If the soundness of Muller's method be admitted, and we have no grounds upon which to base an objection, it is now possible for us to calculate from the data in Table I the chances of finding the correspondences present in twins "A" and "O" in any two members of this family not of monozygotic origin. With the kindly assistance of Professor Sewall Wright, who has taken a most conservative method of calculating the probability, we are able to show that there is only one chance in nearly two thousand that these twins "A" and "O" are dizygotic. This then should make any further proof of the monozygotic origin of this pair of twins unnecessary, and we may now proceed to a study of the resemblances and differences present at the age of nineteen years.

Complete resemblance is perhaps to be expected in monozygotic twins unless differences of environment or in the processes of differentiation introduce lack of resemblance. We have dwelt sufficiently upon the likenesses of the twins: from here on we shall concentrate upon their differences, for

in identical twins the problem is not so much why they are alike as why they are different.

### Differences in the Twins "A" and "O"

*Physical differences.* Going down the list of physical characters in Table II, we may note the following differences. In stature there is but an eighth of an inch difference in favor of "O", less than an individual varies in the course of a day. In weight there are nine and seven-eighths pounds in favor of "O", but there was less difference earlier in life. Even in the last month "A" has varied four or five pounds. In circumferences of parts of the body and limbs there are slight differences everywhere, the greatest being in the thigh, in which that of "O" is one and one-half inches greater. There is always less difference in parts that are less covered with flesh, such an ankle and wrist. "O's" head length is 4 mm. greater than "A's" and her head width is 2 mm. greater. This is interesting in view of the fact that the larger head occurs in the right-handed individual and is associated in this case with higher mental capacity. The cephalic index is .777 for "A" and .771 for "O", which is as close as is usually found in identical twins.

The hair color of the twins is exactly the same, described as "a live dark brown, with golden glint in the sun". Hair of both is naturally straight but curls easily. "O's" hair is noticeably more abundant than "A's" at the present time. In both twins the crown has a clockwise whorl.

The color of the eyes is hazel brown in both, with greenish or bluish radiations from the pupil, but there is a little less of the green in "A's" eyes than in "O's". This gives the impression that "A's" eyes are a little darker.

The ears are very similar, but not identical. The upper lobe is more rolled over in "O's" than in "A's", but there is more difference between "A's" own two ears than there is between the two right ears of or the two lefts. The teeth of the two girls are nearly identical. In both the upper incisors are crowded, the second incisor on the left being crowded out of line in both, another instance of same-sided asymmetry so characteristic of monozygotic twins.

As a child "A" was naturally left-handed, but has been largely trained out of it. She still throws and bowls in cricket with her left hand. In clasping hands she has her left thumb on top. She holds a broom and a baseball bat like a left-handed person. In motor tests, such as wrist and finger tapping, needle threading, pencil tapping in squares cutting out paper stars with scissors, she shows almost equal facility with the two hands except in the tapping in squares with a pencil, in which case she is better with the right hand. This latter performance is, of course, closely allied to writing, and "A" has been trained to write with the right hand. In dynamometer tests for hand strength, "A's" left is a little stronger than her right. "A" then may be safely classed as a natural left-hander. "O", on the other hand, is strongly right-handed in everything and has never had any left-handed tendency. She places the right thumb over in clasping the hands. There is then, in handedness, a distinct reversal of asymmetry between the twins, a situation very common in monozygotic twins, and especially characteristic of the less strikingly similar pairs.

In facial expression there is a marked difference, that of "A" being a little harder and more sophisticated. The mouth is somewhat more set, the jaw a little firmer, and the eyes are kept a little more closed. Whether this difference is due to different experiences in life or is merely the same in kind and origin as are differences in the two sides of the face of a single individual (which are commonly quite considerable), it is impossible to say. But it seems more probable, owing to the

fact that monozygotic twins reared together sometimes show equally great differences in expression, that in the present case the difference is the result of an internal asymmetry mechanism, a phenomen that is to be discussed in some detail in another connection.

### Differences in Diseases, Schooling, and Social Contacts

*Health record of "A".* At birth "A" was very weak and it was thought she would not live. She had scarlet fever at five years, measles and whooping cough at seven or eight years; has suffered a good deal with tonsilitis and bronchitis, and has had some rheumatism since coming to Canada. She still has her tonsils.

*Health record of "O".* "O" was stronger at birth. She had measles at seven, chickenpox at eight, diphtheria at nine or ten (anti-toxin used); she has suffered with tonsilitis and bronchitis a good deal, and had tonsils removed at nine years. She has had a good deal of rheumatism of the same sort as that of "A".

*School record of "A".* "A" started public school near home in Chelsea at five years two months, finishing the nine-year course at fourteen years of age. She then entered Westminster Training School for an eighteen-month business and stenography course. She did poorly in school up to eleven years and after that time averaged about 90. She has worked in offices ever since she left school.

*School record of "O".* "O" started public school at five years eight months; was out most of a year when eight, repeating the grade the following year. She stood first in her class before entering Collegiate Institute (corresponding to our high school), her grades being always above 90. She skipped the last year of grade school and entered the local Collegiate Institute at fourteen years, where she took the commercial course for two years. She has been working in offices since sixteen years of age.

### Differences in Social Environment

*Environment of "A":* Her home until a year ago has always been Chelsea, an old middle-class section of London that has deteriorated in recent years, I am told. Her foster-parents were not so well-to-do as those of "O" and they had four daughters of their own to bring up, all considerably older than "A". "A" therefore, got little special attention. She has been interested in church activities for several years. Although she occasionally walks home with a young man, she seems to have had no serious love affairs.

*Environment of "O":* She has always been the only child in the home of her faster-parents in Oshawa, Ontario, now a town of about 15,000 to 20,000 population. The impression of the home is that it is relatively large and well furnished and that the social status of the family is about the average. "O" has always been more or less "spoiled," being an only child in the family. The effects of this are seen in the fact that she wants her own way and is inclined to dominate "A," who admits that "O" is brighter. Like "A," she has never been much interested in boys or young men, though she enjoys their company at church socials.

*Differences between "A" and "O" in Mental Traits:* At this time I should like to express my appreciation of the fine cooperation given us by these twins. They took the work seriously and each did her very best on all the tests given. The examinations were conducted by Mrs. Blythe Mitchell, who has had years of experience in this kind of work, having conducted all the examinations in the study of foster-children for Professors Freeman and Holzinger as well as those of over a hundred pairs of twins reared together. The examinations were scored by Mrs. Mitchell and Professor F. N. Freeman. The following rather extensive list of tests was given.

1. Stanford-Binet Test.
2. Thurstone Psychological Examination Test.
3. Otis Self-Administering Test.
4. International Test—as worked out by Dr. Stuart C. Dodd.
5. Stanford Achievement Test.
6. Downey Will-Temperament Test.
7. Woodworth - Mathews Questionnaire of Emotional Stability.
8. Kent-Rosanoff Association Test.
9. Pressy X-O Test of Emotions.
10. Strong Vocational Interest Blank.
11. Motor Tests (including tapping with finger and wrist, tapping in squares, needle threading, paper cutting) with both hands.

The results of these tests will be presented in the order given.

1. *Stanford-Binet Mental Test.* "A" required two hours twelve minutes; "O" one hour twenty-five minutes. "A" was hesitant but deliberate when started; "O" replied quickly, but often changed her mind and offered many spontaneous corrections. Although they were both cooperative, the test was more of a task for "A" than for "O," the latter appearing to enjoy the performance. Results of the tests may be thus tabulated:

| | "A" | "O" |
|---|---|---|
| Mental age | 13 years 7 months | 15 years 6 months |
| Intelligence quotient | 84.9 | 96.9 |
| Group | dull and backward | normal |
| Basal year | X | XII |
| Vocabulary range | 10,440 | 12,600 |

The significance of the differences shown here will be seen when it is stated that the average difference in mental age of fifty pairs of identical twins reared together is 8.4 months, that the average difference in I. Q. in the same group is 5.33. There is between "A" and "O" a difference of 23 months in mental age, nearly three times as great as the average difference of fifty pairs of identical twins reared together; and there is a difference of 12 in I. Q., considerably over twice the average noted in identical twins reared together.

2. *Thurstone Psychological Examination*: This is designed to test the upward ranges of intelligence and is much more difficult than the Stanford-Binet test. The table below gives the results. Out of sixty-nine items attempted "A" was correct in thirty-eight; while "O" attempted ninety-four and was correct in sixty-nine.

*Scores*

| | Maximum | "A" | "O" |
|---|---|---|---|
| Completion | 80 | 16 | 20 |
| Artificial language | 74 | 11 | 20 |
| Analogies | 48 | 18 | 38 |
| Arithmetic | 80 | 8 | 20 |
| Opposites | 81 | 24 | 45 |
| Total | 363 | 77 | 143 |

The percentile rank of any score is based upon the results of examining 16,554 freshmen university students and indicates just where this score falls in the whole group. Thus the percentile rank of gross scores of "A" is .184 and of "O" is .697, a difference of .513. This means that, in a group of one hundred students arranged in the order of their ranking in gross score, "O" would be thirtieth from the top and "A" eighty-second from the top. Fifty-two students, or over half of the whole group, would rank between them. Only about 18 per cent. of college freshmen made poorer scores than "A" and about 70 per cent poorer than "O." "A" is in the last quartile (lowest fourth) and "O" in the third quartile (next to highest fourth).

3. *Otis Self-Administering Test of Mental Ability*: The results are shown in the following tabulation:

| | Items Answered | Items Correct | Items Omitted | % Correct of Those Attempted |
|---|---|---|---|---|
| "A" | 47 | 25 | 1 | 53% |
| "O" | 48 | 39 | 6 | 81% |

| | Score | Binet Mental Age Equivalent | I. Q., Using 16 Years as Age | I. Q., Using 18 Years as Age |
|---|---|---|---|---|
| "A" | 25 | 13 yrs. 7 mos. | 93 | 90 |
| "O" | 39 | 16 yrs. 6 mos. | 111 | 108 |

In this test there are ten item groups, intended to rate various forms of mental ability. The scores of the twins are shown in the table below in which the scores on items are grouped according to Muller's classification:

| | "A" | "O" |
|---|---|---|
| 1. Hard directions | 1 | 3 |
| 2. Arithmetical problem | 5 | 6 |
| 3. Logical relations | 5 | 10 |
| 4. Opposites | 6 | 9 |
| 5. Disarranged sentences | 1 | 1 |
| 6. Number series completion | 0 | 1 |
| 7. Analogies | 3 | 4 |
| 8. Proverbs | 2 | 4 |
| 9. Syllogisms | 2 | 1 |
| 10. Geometrical relations | 0 | 0 |
| Totals | 25 | 39 |

"O" proved to be superior in seven groups, equal in two, and inferior in one, namely, syllogisms. As judged by the mental age rating, this test shows an even greater disparity between "A" and "O" than either of the previous tests. This, however, is a time, or speed, test and "O" always works faster than "A."

4. *International Test.* This test stands alone among mental tests used here in the fact that no words are used and no school training is definitely reflected in the materials used. It is largely pictorial in character and is free of national peculiarities. The result is summarized as follows:

| Test | Score of "A" | Score of "O" |
|---|---|---|
| 1. Cube counting and matching | 6 | 6 |
| 2. Matching associated pictures | 22 | 27 |
| 3. Pictorial similarities | 14 | 17 |
| 4. Similarities of facial expression | 7 | 13 |
| 5. Mazes | 7 | 10 |
| 6. Rhythm series completion | 28 | 42 |
| 7. Pictorial analogies | 13 | 31 |
| 8. Narratives or time series | 14 | 27 |
| | 111 | 173 |

In only one of the eight sections of the test is "A" equal to "O," and this is the simplest of them. In all the others "O" excels markedly, her greatest superiority being shown in No. 7, pictorial analogies, which involve more abstract reasoning than the other tests.

5. *Stanford Achievement Test.* The test given was the Advanced Examination: Form A. It should be emphasized that this is an achievement test signifying learning and experience. A part of this test dealing with history and literature is somewhat unfair, since the questions deal to some extent with matters pertaining to the United States. In this section "O", reared in Canada, would be expected to score higher than "A", reared in England. The other sections of the test are apparently fair to both.

| | Score | | Age Equivalent in Years and Months | |
|---|---|---|---|---|
| | "A" | "O" | "A" | "O" |
| Paragraph meaning | 86 | 102 | 15-10 | 18- 6 |
| Sentence meaning | 78 | 72 | 19- 7 | 17- 4 |
| Word meaning | 72 | 83 | 16- 5 | 18- 8 |
| Total reading | 236 | 257 | 16- 8 | 18- 4 |

| | Score | | Age Equivalent in Years and Months | |
|---|---|---|---|---|
| | "A" | "O" | "A" | "O" |
| Arithmetic computation | 96 | 148 | 11- 6 | 17- 2 |
| Arithmetic reasoning | 72 | 96 | 12- 7 | 14- 9 |
| Total arithmetic | 168 | 244 | 11-11 | 14- 9 |
| Nature study and science | 55 | 69 | 13- 2 | 15- 4 |
| History and literature | 49 | 63 | 14- 0 | 15- 5 |
| Language usage | 46 | 52 | 16- 8 | 17-11 |
| Spelling | 202 | 206 | 18- 1 | 18- 6 |

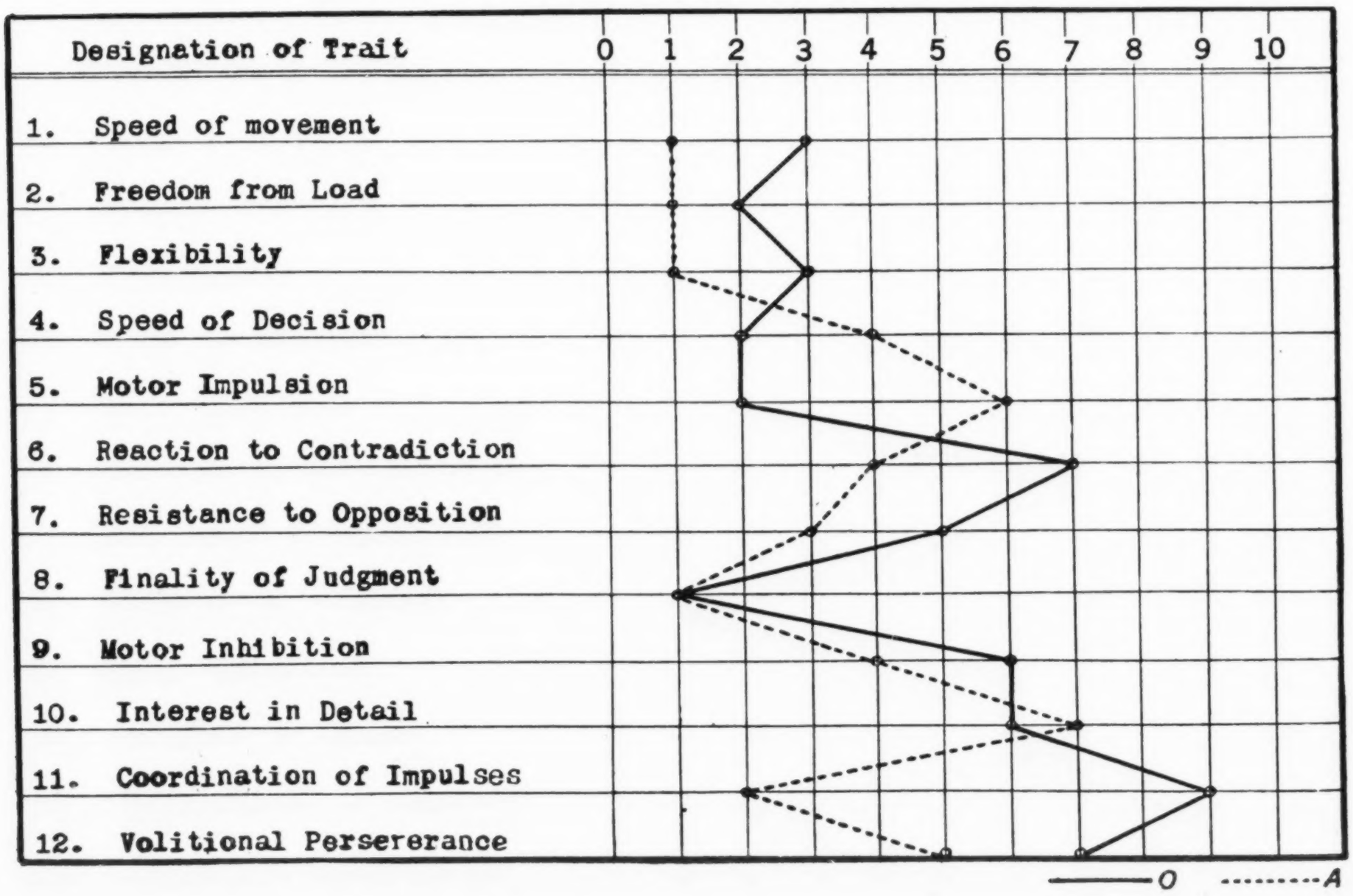
The composite score of "A" is 75.6 and of "O" is 89.1. In terms of educational age, "A" is 15 years 1 month; "O" is 16 years 8 months. "O" excels in every category except "sentence meaning," in which "A" rates noticeably higher.

6. *Downey Individual Will-Temperament Test.* As the name indicates, this test is intended to bring out somewhat different qualities than the previous tests. The tasks assigned are such as to try the patience, temper, and perseverance of the person examined. Without attempting further to characterize the test, it may be said that the scores are usually shown graphically by marking off points on a scale and joining these by lines as in the "Will-Profile" shown in Table III.

"High scores on such a combination of traits as speed of movement and of decision, freedom from load, flexibility, and motor impulsion, characterize an individual as mobile or rapid-fire in organization." These are the first five traits in the Will-Profile, on which the girls both make low scores. Hence, neither twin is a rapid-fire or mobile worker.

"A" ..... 1, 1, 1, 4, 6, = 13 ÷ 5 = 2.6
"O" ..... 3, 2, 3, 2, 2, = 12 ÷ 5 = 2.4

TABLE III—"Will Profile"—Downey Will-Temperament Test



"High scores on a combination of motor inhibition, interest in detail, coordination of impulses, and volitional perseveration characterize the controlled, deliberate, careful person." These are the last four traits of the Will-Profile. Both girls average higher than on the first group.

"A" ..... 4, 7, 2, 5, = 18 ÷ 4 = 4.5
"O" ..... 6, 6, 9, 7, = 28 ÷ 4 = 7.0

"A" is average in these qualities, "O" above the average, indicating that "O" is more controlled, deliberate and careful than "A".

"High scores on motor impulsion, assurance, resistance, finality of judgment, and motor inhibition show a strongly aggressive or forceful person." These are the middle group of items in the Will-Profile. Both twins rank low in these respects, as shown by the following scores:

"A" ..... 6, 4, 2, 1, 4 = 18 ÷ 5 = 3.6
"O" ..... 2, 7, 5, 1, 6 = 21 ÷ 5 = 4.2

In general, the will-temperamental qualities of the two girls are similar. In only three of the twelve traits is there a difference of more than two points in their ratings. In "coordination of impulses" the difference is seven points; in "reaction to contradiction," three points. The average difference in their rating is 2¼ points.

"A very low total (below 40 or 50 points) would indicate some striking deficiency in will-temperamental qualities. A high total score (over 90) would suggest considerable force of personality." "O's" total is 53, "A's" 39, indicating that neither is strong in the will-temperamental qualities, but that "O" has considerable more force of character than "A".

The most striking fact, however, that is brought out by the will-temperamental test is that the twins are so closely similar in their temperamental make-up. The resemblances are more significant and striking than the differences. This is in contrast with the results of intelligence tests, which emphasize the great difference between these girls.

8. *Kent-Rosanoff Association Test.* The results of this test indicate that the girls are very much alike in the distribution of value of their reactions: Thus 46 per cent of the reactions of "A" were the same as those of 50 out of "1,000 normal subjects," while 50 per cent of the reactions of "O" were of this kind, indicating slightly greater deviation from the normal than in the case of "A". The average value of reactions (computed from the sums of actual values) gives "A" a score of 120 and "O" a score of 110. This indicates that "A" in this test comes a little closer to the normal than "O", or, in other words, the reactions of "A" were the same as 120 of the "1,000 normal subjects" and those of "O" the same as 110 of these.

Of all the tests given, this one showed the least difference between the twins, once more emphasizing their temperamental similarity.

9. *Pressy X-O Tests.* These are tests designed to bring out resemblances and difference in emotions. The results are tabulated below:

| | | "A" | "O" |
|---|---|---|---|
| *Test I* | | | |
| Unpleasant words crossed out | Disgust | 20 | 16 |
| | Fear | 9 | 7 |
| | Sex | 8 | 8 |
| | Self-feeling | 10 | 6 |
| | Total | 47 | 37 |
| *Test IV* | | | |
| Worries | Suspicious paranoid | 1 | 0 |
| | "Jumpy" neurotic | 2 | 1 |
| | Self-conscious, shut-in personality | 3 | 3 |
| | Melancholic | 5 | 3 |
| | Hyperchondriacal | 1 | 1 |
| | Total | 12 | 8 |

In the matter of deviation from the "word commonly chosen," which is known as the *idiosyncracy score,* there is a difference of some consequence. The score of "A" is 51 and of "O" 55, as compared with the median which is 47.2.

To illustrate, it may be stated that the worries of "A" concern: self-consciousness, sleep, failure, queerness, dizziness, ugliness, loneliness, and nervous breakdown. Those of "O" have to do with: self-consciousness, discouragement, conscience, failure, ugliness, visions, and darkness.

As to total scores the twins are distinctly similar, 154 for "A" and 150 for "O", and are very low as compared with the college group used as the standard, the median of which is 230. Here, again, similarity between the twins is much more striking than difference.

10. *Strong Vocational Interest Blank.* Any full report of this test would occupy several pages. A brief summary of the main points of resemblance and difference must suffice at this time. In vocational likes they agree quite closely. Both girls are at present typists and stenographers, but "A" dislikes typing and "O" is indifferent about it. The two girls agree more closely on amusements and recreations than on occupations. In school subjects "A" dislikes none, "O" dislikes algebra and geometry. "A", however, never studied geometry. In connection with activities there were nine disagreements out of fifty items. In attitudes toward peculiarities of people, there were five disagreements out of forty-eight items. Some of the differences indicated in the replies deserve special mention: "A" would rather develop plans than execute them; "O" would rather execute plans than develop them. "A" prefers people who talk very loudly to those who talk very low. "A" has just the opposite preferences. On the whole, however, the likenesses stand out much more prominently than the differences.

11. Since the motor tests were referred to in discussing handedness, no further comment about them is needed here. The details are given in Table IV.

### Summary of Psychological Tests

It will be of interest to compare the results of our tests with those published by Muller. The tests that were used in both studies are as follows:

1. Otis Self-Administering Test.
2. Kent-Rosanoff Association Test.
3. Downey Individual Will-temperament Test.
4. Pressy X-O Tests.
5. Tapping Tests.

Muller used the "Army Alpha Test," while we used instead the Stanford-Binet and Thurstone Tests, which are supposed to test the same mental qualities as the "Army Alpha Test"; but the Thurstone test applies to a somewhat higher level of capacity, giving greater possibilities for differences to appear in higher ranges of intelligence.

While Muller's twins appear, in spite of the differences in environment and training, to be nearly identical in mental capacity as measured by these tests, the twins dealt with in this paper are very different in mental capacity, the difference being nearly three times as great as the average of fifty pairs of identical twins reared together. Muller also found that in his twins there was the greatest difference with regard to emotional reactions (on the whole of the same order as for two unrelated persons taken at random), while in the case of our twins the resemblances in emotional reactions are far greater than in the more strictly mental qualities.

In this connection it may be said that the results of the intelligence tests correspond in some detail with the judgments of the twins about themselves and those of relatives about them. "A" says that "O" is "smarter than I am. She catches on to things quicker and remembers better." The foster-mother of "O" says: "Of the two girls, 'O' is the brighter. She knows just what is to be done. She is the leader and

has more initiative." The opinion of the family in general is that "O" has had somewhat superior educational and home advantages. The foster-mother's opinion of the two girls is that they are alike in many ways; both are hasty in action and in judgment, "A" a little more so. Both are high-tempered, but "O" has learned to control herself better than "A".

## Discussion

There can be little, if any, doubt that these twins have been derived from a single zygote and are therefore genetically identical. The question arises as to what are the factors responsible for the rather marked differences between them. Lest it be thought that the mental differences, great though they be, are unparalled among identical twins, it should be stated that there are among our fifty pairs of identical twins reared together, five cases, or 10 per cent of the whole group, that show an equally great or slightly greater difference in I. Q. (as based on the Stanford-Binet Test), than do "A" and "O". "A" and "O" showed a difference of 12 in I. Q.; while the five pairs of identical twins reared together showing greater differences run as follows: 12.6, 12.9, 13.0, 13.9, and 16. It might also be said that five pairs of

**TABLE IV—Motor and Handedness Tests**

| | "A" | | "O" | |
|---|---|---|---|---|
| | Right | Left | Right | Left |
| Wrist tapping (total for 3 trials of 5 seconds each) | 102 | 100 | 103 | 87 |
| Finger tapping (total for 3 trials of 5 seconds each) | 73 | 75 | 89 | 65 |
| Needle threading (total time for 3 needles) | 27 sec. | 30 sec. | 25 sec. | 62 sec. |
| Pencil tapping in squares (total number of taps for 3 trials of 10sec. each, given in order: (1) Right hand, (2) left hand, (3) right hand, (4) left hand) | 98 (1) | 97 (2) | 113 (1) | 103 (2) |
| | 118 (3) | 103 (4) | 117 (3) | 104 (4) |
| | 216 | 200 | 230 | 207 |
| Cutting out stars (total time for 3 stars with each hand--given in order--R.L.R.L.R.L) | 123 sec. | 139 sec. | 102 sec | 165 sec. |

our fifty showed 0.0 difference in I. Q. as based on the Stanford-Binet Test.

Since, then, differences in intelligence as great or greater than that shown between "A" and "O" do occur in some cases of identical twins reared together, it might be concluded that these differences are of no great significance as criteria of the effectiveness of different environment and training. It should be emphasized, however, that in all of the five cases of twins, just referred to, in which there was an unusually wide discrepancy in I. Q. as tested by the Stanford-Binet Test, there was much closer correspondence in all other mental tests given. In contrast with this is the fact that our twins "A" and "O" are consistently far apart in all the scores derived from pure intelligence tests, and "O" is always distinctly superior.

The general conclusion might be that in this pair of twins differences in environment and in training have been responsible for bringing about a significantly great divergence in intellectual ability, but that their temperamental or emotional traits have remained unusually similar. On the basis of this one case alone, one might conclude that emotional and temperamental characteristics are more strongly inherited than purely mental traits. It should not be forgotten, however, that Muller's case points to an exactly opposite conclusion. Here, then, are two studies pointing to opposite conclusions. Is one right and the other wrong, or are both right? My opinion is that it would be decidedly premature to generalize on the basis of either case. We badly need more cases, and, fortunately, at least two more have been studied in detail and will be dealt with in subsequent papers in the present series. Until these other cases have been described it would be wise to hold all general conclusions in abeyance.

**Literature Cited**

1. Muller, H. T. 1925. Mental Traits and Heredity. *Journal of Heredity*, Vol. 16, No. 12.

2. Newman, H. H. 1922. Twins and the Relative Potency of Heredity and Environment in Development. *Publications of Amer. Social Soc.*, Vol. XVII.

3. ————. 1928. Studies of Human Twins:

I. Methods of Diagnosing Monozygotic and Dizygotic Twins. *Biol. Bull.*, Vol. LV, No. 4.

II. Asymmetry Reversal, or Mirror-imaging, in Identical Twins. *Biol. Bull.*, Vol. LV, No. 4.

## Mongolism in Twins

THE causes of Mongolism have been discussed a number of times in this Journal, but the final solution appears not yet to have been reached. An exhaustive study of the subject has recently appeared,* which discusses the matter in detail, but without very definite conclusions:

That Mongolian imbecility cannot be a reversion to primitive Mongol type since the resemblance to the Chinese or Japanese race is mainly superficial and since, furthermore, the condition is a pathological one.

That Mongolian imbecility is not due to parental alcoholism, tuberculosis, or syphilis although these conditions may in many cases be powerful contributory agents.

That Mongolian imbecility is not due to neuropathic heredity. Careful investigation of cases shows that the family history is generally good and we find that the brothers and sisters of Mongols are, with very few exceptions, mentally and physically normal.

That Mongolian imbecility is not due to extremes of age in one or both parents. The advanced age of the mother may be a potent contributory cause but it is not alone sufficient to explain the condition; we find many Mongols born to mothers who are under 35 years of age.

That Mongolian imbecility bears no relation to the order of birth or to the number

*Mongolism, a study of the Physical and Mental Characteristics of Mongolian Imbeciles, by Kate Brousseau and H. G. Brainerd. Pp. 203. 47 illus. $4.50. Williams & Wilkins. Baltimore, 1928.

of children in the family. An examination of 800 cases shows that 57.49 per cent of Mongols belong to families where the Mongol was the first, second or third child.

That Mongolian imbecility is not due to mental strain. Many mothers report that the pregnancy resulting in the birth of a Mongol was calm, uneventful and altogether free from anxiety; furthermore statistics show that Mongolism did not increase in the warring countries during the World War, although pregnant women were subjected as never before to continued terror and anxiety.

That Mongolian imbecility has not for its essential cause some disease of the maternal reproductive organs or undernourishment or overwork of the mother during pregnancy. If such were the cause it would be difficult to explain the condition of Mongolism in one of twins.

That Mongolian imbecility is possibly induced by some obscure disturbance of the ductless glands. There may be inherited or congenital glandular instability, or the mother during pregnancy may develop certain endocrine disorders which may be transmitted to the child. Further investigation may show that Mongolism is the result of a pluriglandular syndrome or the disfunction of some particular gland. Some endocrine disturbance can be demonstrated in every Mongol.

Very detailed accounts are given of the physical and mental characteristics of these unfortunates. Many physical defects accompany the condition, and perhaps it is just as well that their mental development is so slight that they can scarcely appreciate their deplorable plight.

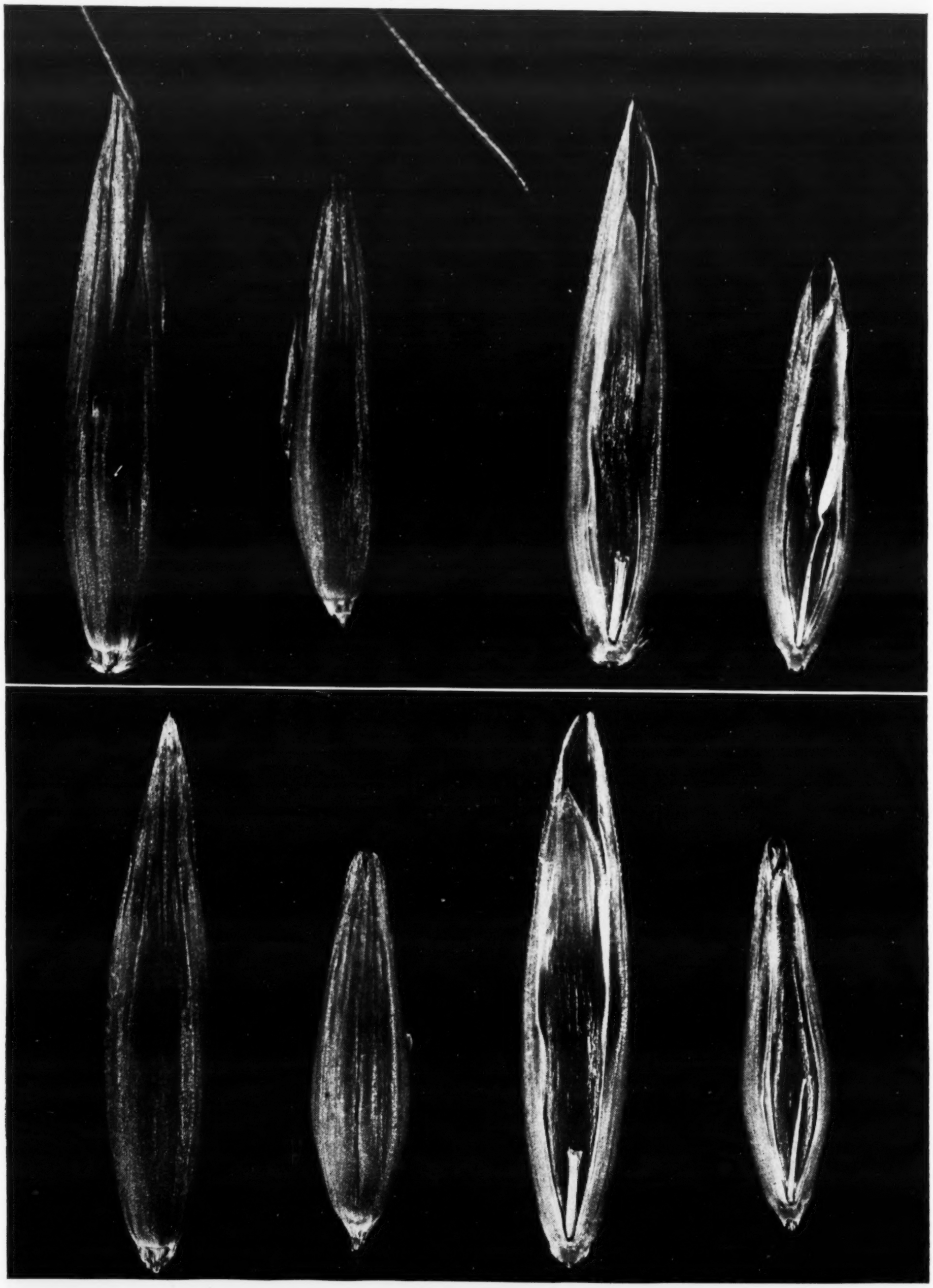
It is rather surprising that the authors fail to attach greater importance to the interesting data on Mongolism in twins which they have brought together. Thirty-two cases are reported in which Mongolism has occurred in one of a pair of twins. In eighteen of these cases the twins were described as "dizygotic." In four cases the sex of the twins was not known. In the other cases the zygocity of the twins was in doubt. In five other cases Mongolism was recorded in allegedly monozygotic twins,—both twins being affected. The fact that Mongolism does occur in one twin and not in the other would seem to rule out most of the environmental factors except differences in interuterine environment. The lack of clear-cut cases of identical twins differing in respect to Mongolism also suggests an hereditary cause. Apparently the intensive study of twins with Mongolism offers the most promising method of arriving at an understanding of the condition. The cases in which the classification of the twins as identical or fraternal remains in doubt should be thoroughly investigated, for the discovery of a single case of identical twins differing with respect to Mongolism would be of the utmost importance, and would dispose fairly conclusively of heredity as a cause of the condition.

The illustrations emphasize the remarkable similarity in the appearance of Mongolian idiots, and to the reviewer this suggests that a definite cause, or chain of causes, will eventually be found. The absence of family histories of Mongolism does not conclusively dispose of heredity as the cause of the condition. As an example of a somewhat analogous situation the work of Wright and Eaton on otocephaly in Guinea Pigs might be cited.* An inbred family of guinea pigs was separated into two lines, one of which had a very much higher percentage of otocephaly than the other. It was concluded that the condition was unquestionably inherited, but the mode of inheritance has not been determined. An examination of the number of individuals and generations comprised in a human family history would have given no hint of the genetic nature of the condition.

If such should prove to be the case it is reassuring that the authors report no authenticated case of Mongols having children, and the tendency for Mongols to be the last child may reflect, among other things, a deliberate limitation of family size with the birth of such a child.

*R. C. C.*

*Wright, S. and O. N. Eaton. 1923. Factors which Determine Otocephaly in Guinea Pigs. *Journal of Agricultural Research* 26:161-182. Illus.



**FLORETS OF YELLOW OATS**

**Figure 3**

Typical florets of intermediate and cultivated forms of Richland and Iogold oats. All are distinctly yellow. The existence of yellow fatuoid forms has been questioned, but their presence in these and other yellow varieties was noted in many parts of the United States.

# YELLOW-KERNELED FATUOID OATS

T. R. Stanton and F. A. Coffman

*Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture*

THE presence of awns on yellow oats has been widely studied with considerable differences in results. Opinions vary as to whether yellow color inhibits awning in oats. Fatuoid oats are essentially awned. Recently the question has been raised as to the possibility of fatuoid or false wild oats occurring in yellow varieties. Some writers report this phenomenon, while others doubt the correctness of color classification in such cases. The writers present the result of a study of fatuoids from yellow oat varieties.

## Awn Development in Yellow Oats

Nilsson-Ehle[5] and other investigators, have reported that yellow color in oats inhibits the development of awns. Coffman and Stanton,[1] however, have observed yellow oats which bore awns.

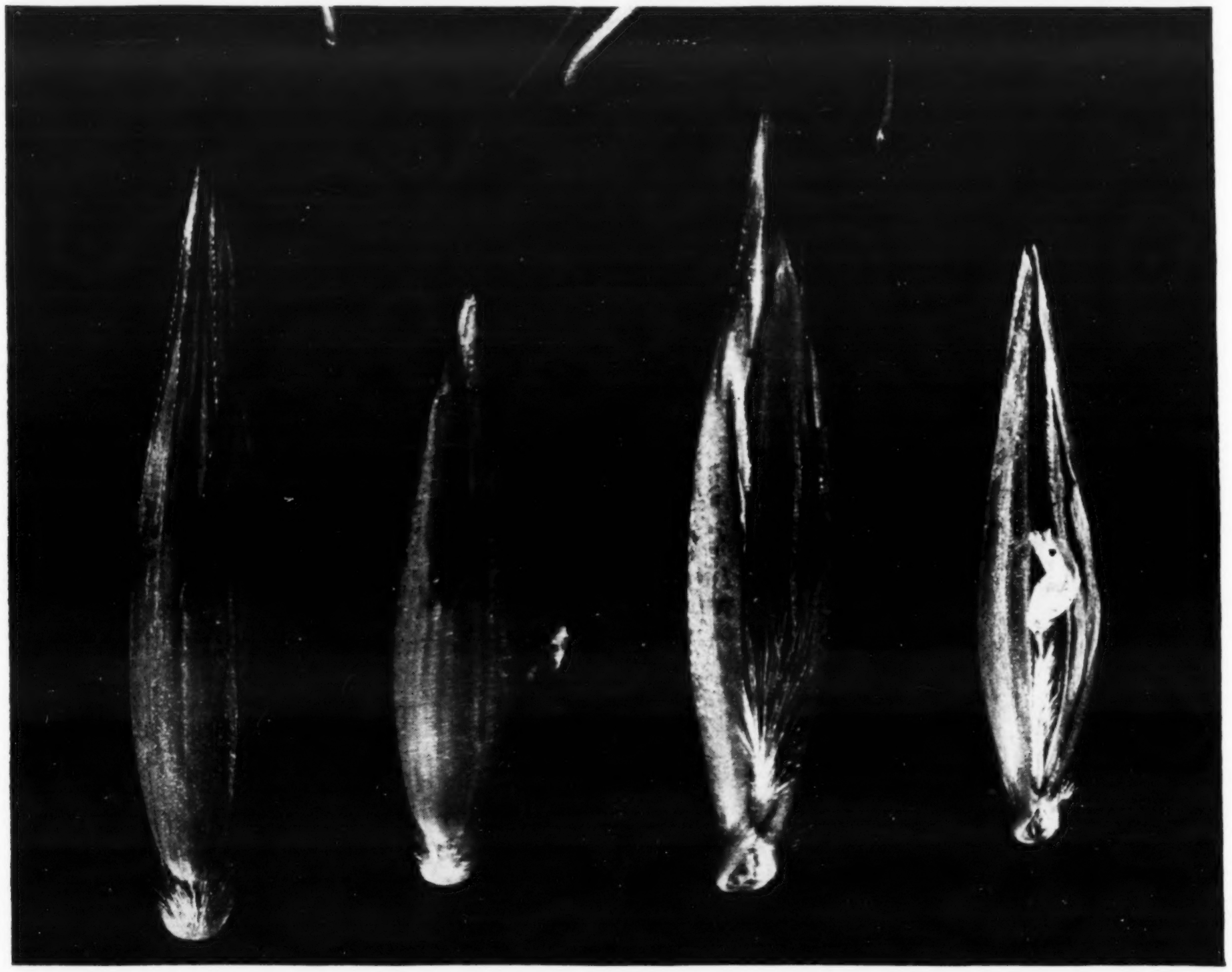
The occurrence of yellow fatuoids in yellow-kerneled varieties has been reported by Crepin,[2] Garber,[3] and Stanton, Coffman, and Wiebe.[6] The color interpretation of these investigators has been questioned by Jones[4] who points out that no data are available to show whether these color determinations were made on immature or on fully-matured, well-dried specimens.

Jones,[4] as the result of his studies on the absence of yellow color in certain fatuoids or false wild oats, intimates the possibility of yellow color inhibiting the occurrence of fatuoids in oats. He observed a single fatuoid plant in Golden Rain oats. This aberrant did not show the yellow color of the parent variety, but was white. He crossed descendants of this fatuoid plant with plants of the parent variety. The $F_1$ was characterized by almost complete absence of yellow color. In $F_2$ a similar absence of color was observed in those segregates containing the fatuoid characters either in the homozygous or heterozygous condition, with the exception of slight traces of yellow in occasional kernels of a very few plants. The kernels of all non-fatuoid plants, or, as designated by Jones, those having "sativa-type of grain," were yellow. On close examination of the $F_3$ segregates at harvest time it was noted that the fatuoid plants which were fully matured possessed white kernels similar to those of the original fatuoid plant. On the other hand, the fatuoid plants which were less mature showed kernels which were distinctly greenish yellow in color. On drying the latter all evidence of the yellow color disappeared. Numerous Golden Rain kernels treated similarly retained their yellow color. The author somewhat cryptically concludes:

> In conclusion and in view of the inhibitory relationships already recorded, the question may be raised as to whether the loss of colour on ripening, as described in these studies, is to be regarded as an inhibitory effect due to the presence of the fatuoid complex or of some factor associated with it, or whether it should be regarded as an entirely separate phenomenon. The data give support to the latter view.

## Experimental Data

The writers have observed fatuoids in many different oat varieties. They have almost come to the conclusion that sufficient search eventually will disclose these forms in practically all cultivated oat varieties. They have observed fatuoids in several undoubtedly yellow varieties, but until the question was raised by Jones as to the correctness of interpretation, oc-



**FATUOID YELLOW OATS**

**Figure 4**

Fatuoid yellow florets of Richland and Iogold oats,—indicating that the yellow color is not inhibited by the fatuoid character.

currence in yellow varieties was given only casual consideration.

In visiting agricultural experiment stations throughout the United States during the summer of 1927, the writers made a special search for fatuoids in yellow varieties of oats. Fatuoids were noted and collected in Richland (Iowa No. 105) and Iogold, both yellow-kerneled, pure-line selections of the Kherson oat. Collections were made at Ames, Iowa; Mandan and Dickinson, N. Dak.; Moccasin, Mont.; and Aberdeen, Idaho. They occurred under humid, subhumid, and irrigated conditions.

Color notes were taken at the time of collection and all these fatuoids were noticeably yellow. The fatuoids were classified in the field as homozygous or heterozygous on the basis of characters previously outlined by the writers.[6] The specimens were placed in envelopes, air dried for a few days, and mailed to the central laboratory in Washington. Some weeks later these specimens again were closely examined in Washington, and it was found that without exception all had retained their yellow color.

To determine the stability of the yellow color of these fatuoids, progenies of each, varying from 1 to 8 plants, were grown in pots in the greenhouse at the Arlington Experiment Farm, Rosslyn, Va., during the winter of 1927-1928. At maturity these second generation plants were

harvested, and carefully inspected for kernel color. The data obtained are given in Table I.

A total of 136 progeny plants from the 32 original yellow-kerneled fatuoids was available for study. Of this number, 133 were classed as yellow-kerneled, 2 as white-kerneled, and 1 as gray-kerneled. All of the fatuoids classed as homozygous when collected bred true for yellow. The occurrence of gray- and white-kerneled plants in the progeny of one parent plant which was classed when collected as heterozygous fatuoid, may have resulted from natural crossing. The data obtained, however, are sufficient to indicate that yellow fatuoids do occur in some typical yellow-kerneled cultivated varieties, and that they may be expected to breed true for color. Intermediate and normal forms of Iogold and Richland oats are shown in Figure 3; the fatuoid form of these varieties in Figure 4.

## Summary

Yellow-seeded fatuoids were found in the distinctly yellow-kerneled varieties Richland and Iogold. These occurred under a wide range of climatic and other environmental conditions. The observation of these fatuoids, supported by the data on their breeding behavior, is ample proof of their occurrence.

**TABLE I—Classification on the Basis of Fatuoid and Color Characters of 32 Yellow-Kerneled Fatuoids, and of 136 Progeny Plants Grown from Them**

| Variety | Parent plants (all yellow-kerneled) | | Progeny | | | |
|---|---|---|---|---|---|---|
| | | | | | Kernel Color | |
| | Number | Classification | No. of plants | Classification | No. plants with yellow | No. plants with white |
| Richland: | 10 | Homozygous fatuoid | 48 | Homozygous fatuoid | 48 | 0 |
| | 1 | do | 3 | do | 2 | 0 |
| | | | | Cultivated | 1 | 0 |
| | 9 | Heterozygous fatuoid | 31 | Homozygous fatuoid | 3 | 0 |
| | | | | Heterozygous fatuoid | 6 | 0 |
| | | | | Cultivated | 20* | 2 |
| Iogold: | 9 | Homozygous fatuoid | 40 | Homozygous fatuoid | 40 | 0 |
| | 3 | Heterozygous fatuoid | 14 | Homozygous fatuoid | 4 | 0 |
| | | | | Heterozygous fatuoid | 8 | 0 |
| | | | | Cultivated | 2 | 0 |
| Totals: | 32 | | 136 | | 134 | 2 |

*One of these plants was gray-kerneled. Natural crossing may offer an explanation for this variation.

## Literature Cited

1. Coffman, F. A. and Stanton, T. R. 1925. Variation in the Kherson Oat at Akron, Colorado. *Jour. Agr. Research* 30: 1063-1082, illus.

2. Crepin, C. 1921. Sur un Hybride Naturel entre *Avena fatua* et *Avena sativa* à Glumelles Jaunes. (A natural hybrid between *Avena fatua* and *A. sativa* with yellow glumes.) *Ann. Ecole Natl. Agr. Grignon* (1920-21) 7:143-154, illus.

3. GARBER, R. J. 1922. Origin of False Wild Oats. *Jour. Heredity* 13:40-48, illus.

4. JONES, E. T. 1927. Preliminary Studies on the Absence of Yellow Colour in Fatuoid or False Wild Oats. Welsh Plant Breeding Sta. Aberystwyth. *Welsh Jour. Agr.* 3:221-231.

5. NILSSON-EHLE, H. 1914. Ueber einen als Hemmungsfaktor der Begrannungauftretenden Farbenfaktor beim Hafer. *Ztschr. Induktive Abstam. u. Vererbungslehre* 12:36-55. (A noticeable color factor as an inhibiting factor in awn development in oats.)

6. STANTON, T. R., COFFMAN, F. A. and WIEBE, G. A. 1926. Fatuoid or False Wild Forms in Fulghum and Other Oat Varieties. *Jour. Heredity* 17:152-165, 213-226, illus.

# INDUSTRIAL PEASANTS

WHAT human product is to be expected from our highly mechanized industrial system? A tendency to reduce our farming population to the status of peasantry has been recognized, but a recent industrial writer projects a similar future for urban populations as well. Two classes of industrial peasants are distinguished with reference to their chances of survival during periods of depression when factories are closed and the workers face the problem of existence with no resources. A better prospect is indicated for those who have not lost all of their farm abilities. Periods of forced leisure are considered inevitable, when a completely urbanized proletariat does not "get by," except by a return to more primitive conditions of feudalism, as in Europe.

Without the intervention of outside forces, such as enlarged foreign demand, wars, or wholesale destruction of producers, I foresee the gradual but considerable development of two sorts of what might be called peasantry. The buying power of both groups will be somewhat limited. The first group I think of as that of the industrial peasant, who is well fitted to survive. This is the group who work in industry when possible, but take their living off the very small tracts of land. They are self-sufficient and independent. Perhaps we should call them country gentlemen, but they are not true farmers. They produce for their own needs and sell only a part of their labor. As a potential market they are not a large factor.

I have watched with considerable concern these good folk we have laid off, to see how they survive, for I have always felt a moral responsibility for the man who has cast his lot with us. Those who get along best are those who own or rent small tracts of land, have good gardens, raise chickens, keep a cow or two, perhaps a pig. One of my former employees has five acres, and this possession renders him absolutely independent for long periods of time.

Those who do not "get by" are more of the city type, who must buy everything that they consume. The grocer carries them a few weeks, finally cuts off their credit, and they drift away, seldom to return. Of course the grocer loses his money.

My experience in city and country manufacturing leads me to prefer the latter every time, except where highly skilled labor is required in quantity. A worker who has been a farmer is the most resourceful person one can find, because the long years of isolation have developed a self-dependence unequaled in any other group. To one who has had opportunity such as I have had to observe both city and country manufacturing the contrast is astonishing, and labor costs are 50 per cent less in the country than in the city.

However, the worker who is self-sufficient, who produces most of his living, except perhaps shoes and clothing, and frequently has something to sell besides the labor for which he has been hired, is not the potential consumer as is the city type of worker, who must buy everything.

The second group, which I shall term the true peasants, are those who cannot make a go of life in any place independently and whose struggle is for existence itself. The misfits who seldom get a job may go back to the land, if they ever came from there. They cannot exist in town, they are incapable of handling farms. What can they do? In Europe they are usually peasants or retainers, working for five to ten dollars per month and a place to live. Many of them spend their entire lives in that fashion.

A distinguished European told me last month that his greatest surprise on coming to this country was to hear all the talk about getting ahead, whereas in his native land fully half the population were satisfied if

they had shelter and enough to eat. It is hardly possible that America will ever come to such a situation, but the conclusion is inevitable that there are forces at work that tend in that direction.

The downfall of civilization predicted by the world-famous prophets of gloom may or may not come about. If it does occur, it will probably take the following order. One by one the weaker members of our industrial units will be forced out of existence, and those persons previously engaged in such enterprises will seek employment elsewhere. A larger proportion of the people will become more and more self-sufficient by revision to a less specialized form of life. Those who cannot adapt themselves will attach themselves as retainers or peasants, as they do in Europe today, to larger landowners and live on next to nothing, or they will be public dependents.—GRIMES, WALTER HENDERSON, "The Curse of Leisure," in *The Atlantic Monthly*, Sept., 1928, Vol. 142, No. 3, pp. 359-60, rearranged.

Making the industrial system socially self-supporting by the addition of employers' liabilities and old-age pensons systems, no doubt will be a further handicap of urban industrial operations in the future, as contrasted with rural participation in industry. In the later Roman period, the industrial system returned to the simpler form of self-supporting estates in the country where the manufacturing as well as the field work was done by the *coloni*, while the cities decayed. The urban fermentation of the Roman civilization worked itself out, and the return to feudalism began, even before the Gothic invasions. The peasants, "whose struggle is for existence itself" are then forced to become retainers or brigands. The later Roman period is characterized by the absence of intelligent writers to chronicle the changes that took place while civilization was retrograding to the Dark Ages.

By the time that Europe began to emerge from the Dark Ages, the Roman feudal system has become well established among the northern peoples. Social stratification has continued on the feudal basis to the present time, and the peasant status no doubt has tended to preserve the racial abilities of the Germanic peoples against urban selection. For several centuries the forms and traditions of democracy were maintained only in the few "free cities" that were able to resist the barons. It was not till America was colonized that the primitive Germanic traditions of individual and family independence could be revived among rural people. The escape from feudalism, with the discipline and selection of the colonial stock under pioneer conditions, resulted in a period of rapid progress, which was reflected back to Europe through the French Revolution. But our material prosperity and free institutions, by removing all of the social barriers to equal opportunity have exposed us fully to the adverse selection of urbanism. Other forms of human conservation must be sought if the race is to be maintained.

The European agricultural peasants are not to be confused with the urbanized peasants that our industrial system is expected to produce. The peasant land-owners and tenant farmers in some countries still represent the original population to which the feudal system was applied centuries ago . The establishment of the feudal system meant not only dividing up the land into large holdings, but the people also.

. . . All over western and central Europe, in the twelfth and thirteenth centuries, the land was cultivated by serfs bound to the soil. Outside England, the descendants or representatives of these serfs still remain on the land, in all but a few districts; either as "peasant proprietors," owning the acres they till, or as small tenant farmers with something closely approaching in practice to permanence of tenure. In Germany, as a whole, between two-thirds and three-quarters of the land is still owned and cultivated by peasants: peasant properties occupy from two-fifths to two-thirds of the area even of those provinces east of the Elbe which most nearly resemble England in the predominance of large owners; while in the southwest of the empire peasant properties monopolize almost the whole country. In France large estates are distributed more evenly over the several provinces; but in that country, also, quite one-half of the whole land is still in the hands of peasant owners. In England, on

the contrary, by far the larger part of the cultivable area has come to be owned by comparatively few "landlords." . . . Before the recent "agricultural depression," from which the country is now emerging, it was calculated—and no sustantial change in the situation has, as yet, taken place—that 4,200 persons owned between them considerably more than half the soil of England and Wales, and that the owners of the other half, so far as it was really agricultural land, numbered no more than 34,000.—The Economic Organisation of England, *by* SIR WILLIAM ASHLEY, 1925, pp. 2 and 3.

The tendency of the urban industrial system to submerge the interests of rural life has not served to counteract the feudal system, or to place the artizan on the independent, small-land-owner footing so confidently prophesied by Adam Smith in the early years of the "industrial revolution." The industrial system may be only partly responsible for the remarkably restricted ownership of farm lands in England, but the same tendency is now being shown in the United States. The reduction of farmers to the peasant status seems only a normal development from the urban standpoint. To have as many people as possible living in cities is assumed to be desirable. But with a peasant prospect for city people also, a return to feudalism may be expected, as occurred in the later Roman period.

—*O. F. Cook.*

---

## Darwin's Home a Memorial

PERMANENT preservation of Darwin's home at Down, in the County of Kent, is announced in *Nature*, September 8, 1928. Darwin lived most of his life at Down, from September 14, 1842, to the date of his death, April 19, 1882. Eight of Darwin's ten children were born at Down, and his books were written there. Forty years of intensive labor were devoted to observing, experimenting and reporting facts of nature from the new standpoint of evolution.

"No single home in the world can show such a record. Truly, from Down, Charles Darwin shook the world and gave human thought an impress that will endure for all time."

It was given to Darwin to see the wonders of life, and to hold them in a deep and abiding interest, so that he labored through the years to gain a better understanding. He saw in nature the great balance that life is weighed in, and saw this perpetual weighing and winnowing of life as a part of the process of creation. A new heaven and a new earth were revealed through the work of Darwin. As members of such a creation the races of mankind become conscious of many new relations and responsibilities. We live in a new world because Darwin studied and wrote. He was a great apostle of truth, and the scene of his devotion will be a place of pilgrimage for many generations.

The house at Down has been used in recent years as a private school. It now has been purchased from one of Darwin's grandsons, and the ownership transferred to the British Association for the Advancement of Science with an endowment "amply sufficient for its maintenance and preservation for all time." Plans have been made for restoring the furniture and arrangement of Darwin's study during the period when the "Origin of Species" was written. The property is to be used for the benefit of science and regarded as a gift to the nation, open to visitors "every day of the week between the hours of ten and six, without charge".

The author of this benefaction is Mr. George Buckston Browne, fellow of the Royal College of Surgeons of England, and of the Society of Antiquaries, London.

# A RECESSIVE FACTOR FOR POLYDACTYLISM IN MAN

## Studies in Human Inheritance III*

By LAURENCE H. SNYDER

*Genetics Laboratory, Dept. of Zoölogy, N. C. State College, Raleigh*

MANY cases of polydactylism are on record. The character appears to be regularly dominant, although in some instances imperfectly so. Thus, Lucas[4] gives a family history in four generations in which there was one case of failure to dominate. Ballowitz[1] gives several family histories in which polydactyly appears to be dominant. Milles[5] considers the character as a dominant. Castle[2] found the inheritance of polydactyly in guinea-pigs to be not strictly alternative, nor yet truly blending, but rather intermediate between the two. In poultry polydactyly appears to be dominant.[3] The present tendency is to consider extra digits in man as a dominant character with an occasional genotypically dominant individual who fails somatically to show the character.

During the summer of 1928 in connection with an intensive study of human blood groups, a large number of negroes in Pamlico County, North Carolina, were found who showed an extra fifth finger on each hand. Careful family histories were gathered, and the results are presented herewith. Blood group determinations were made on all the living individuals with the hope of determining the linkage relations of the two characters.

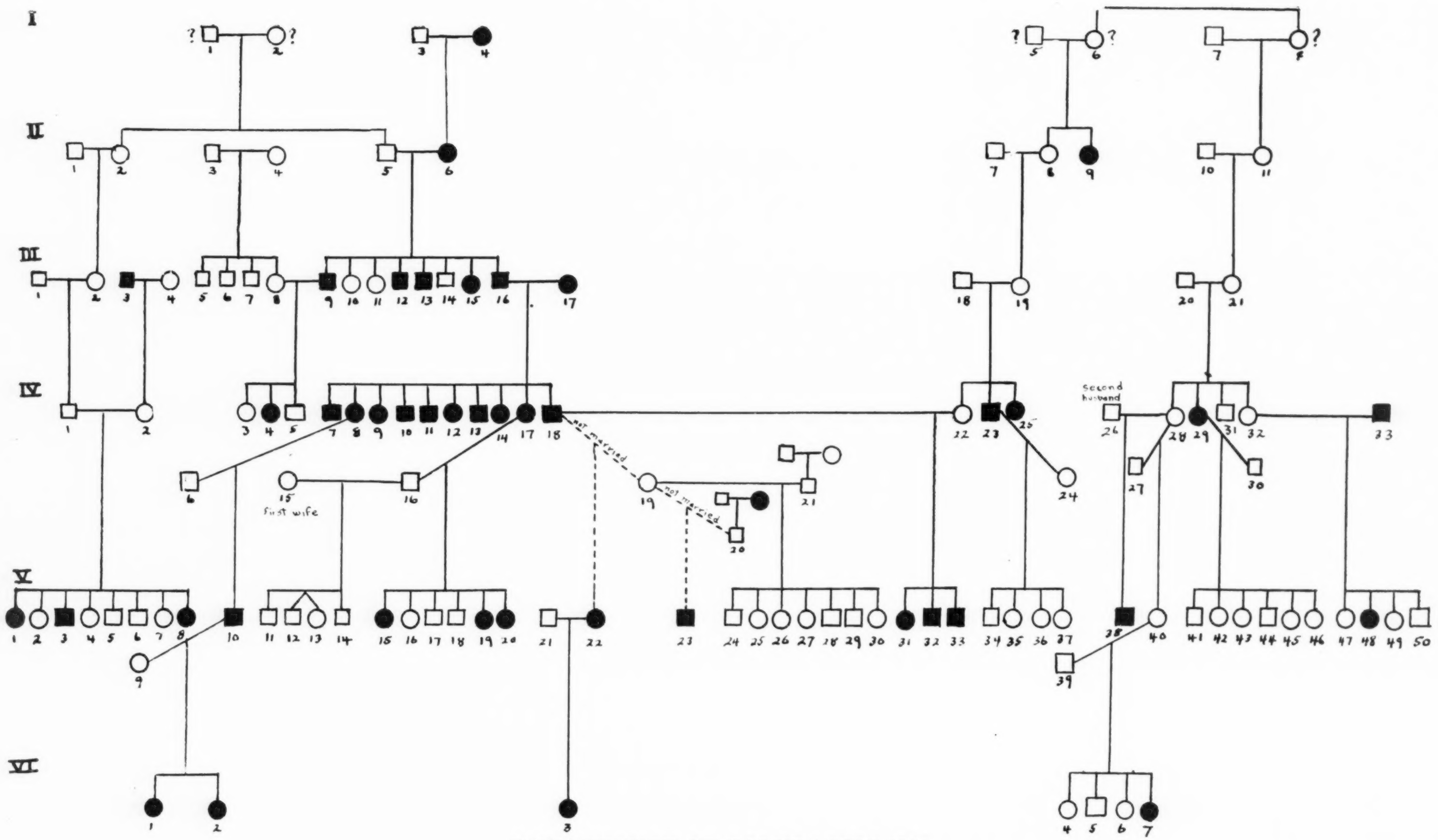
The extra finger was joined to the hand at the base of the little finger. In most cases it was as thick at the point of union as anywhere else, and firmly joined; occasionally it hung by a small circle of skin. In such cases the finger is sometimes amputated shortly after birth, but the scar remains. A photograph of the abnormality is shown in Figure 6.

The first family to be encountered was that of Amos Jones (Figure 5: IV, 18). Amos showed the character, his wife did not, and the three children did. It began to look like the regulation dominant. However, further investigation brought out the fact that although the wife's brother and sister had the character, neither of the parents had it. Both parents of Amos showed the character, and all ten children had the extra fingers. Here was indication that a recessive factor was concerned. Other members of both families were visited and examined. A total of 171 individuals were included in the family histories, 54 of whom had six fingers on each hand. One hundred and twenty of the 171 were personally examined, including members of every generation on the charts except generation 1 of Figure 5.

Several facts soon became apparent. First, the bulk of the individuals could be included in one family chart (Figure 5). Two smaller families were also concerned (Figures 7 and 8). Second, the character frequently skipped generations. Third, all possible types of matings were apparently represented, making possible a critical analysis of the behavior of the factor.

If the abnormality is dominant it must be very imperfectly so, as 14 polydactylous children were born in 11 different families where both parents were normal. This large number of such families almost precludes the hypothesis of dominance, especially as the other criteria for recessiveness are

*Aided by a grant from the American Medical Association. Published with the approval of the Director of Research as paper No. 28 of the Journal Series.




**INHERITANCE OF POLYDACTYLISM**

**Figure 5**

Polydactylism heretofore has been reported as a dominant character. In these families a recessive factor would better explain the facts.



an
litt
joi
a

fu
or
on
so
ma
go
is
Jo
an
du
A
ing
5
dr
ha
ill
no
da
sh

th
dr
pr
of
F
lo
re
de
ar
ag
w

**EXTRA LITTLE FINGERS**

**Figure 6**

In the polydactylism discussed in this paper an extra finger is attached at the base of the little finger. In most cases it is firmly joined, but in some it is attached only by a piece of skin.

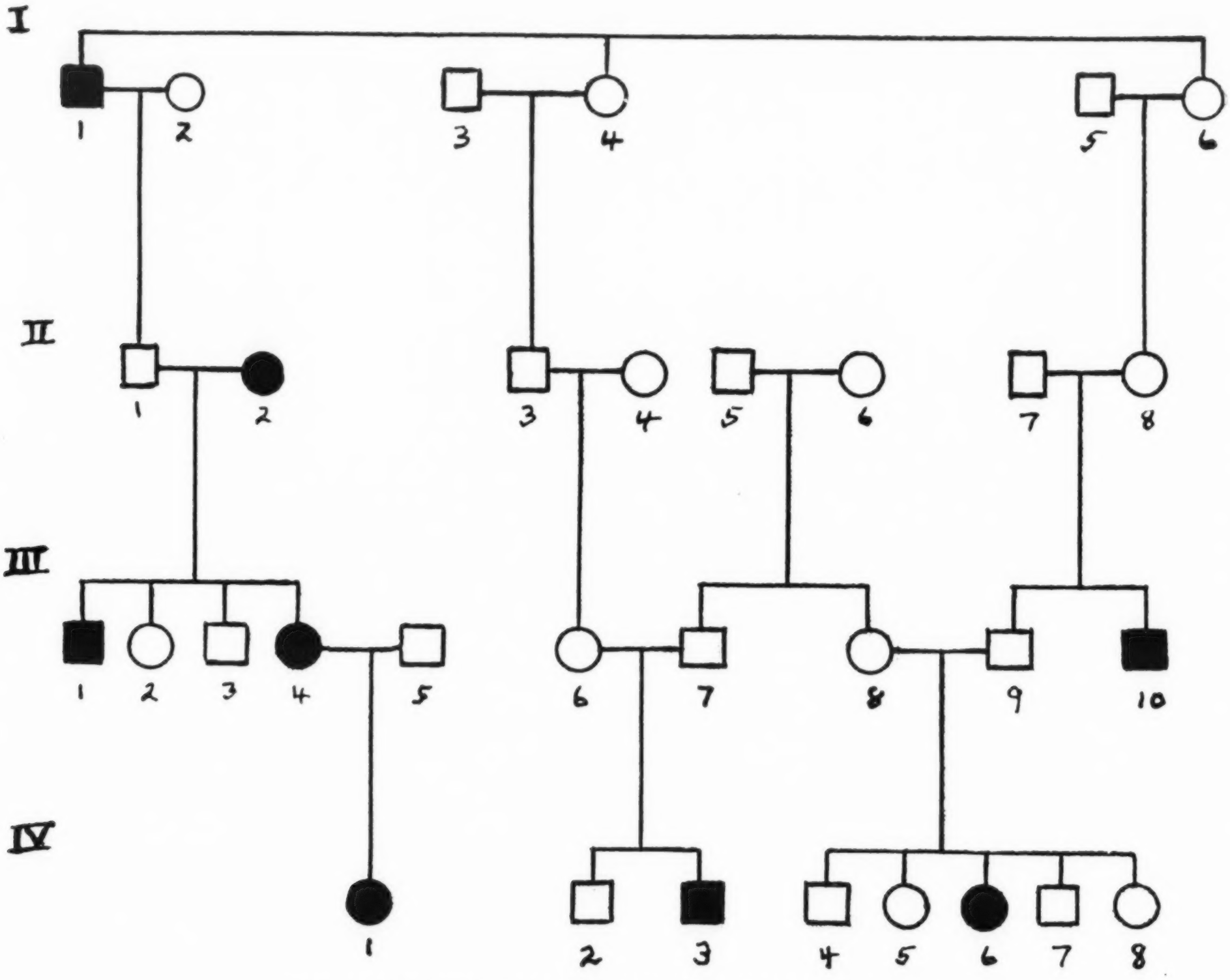
fulfilled. The individuals are all more or less related, and are restricted to one locality (Pamlico County, N. C.), so that all normals producing abnormals could easily have been heterozygous for polydactylism. A critical case is provided in the family of Selwyn Jones (Figure 5: III, 16), where he and his wife, both polydactylous, produced ten children, all polydactylous. Another interesting set of critical matings is the case of the woman (Figure 5: IV, 19), who had seven normal children by a normal man whose family had never showed polydactylism, one illegitimate polydactylous child by a normal man whose mother was polydactylous, and one illegitimate polydactylous child by a man who himself showed the abnormality.

Where one parent is polydactylous, the other normal, polydactylous children should make up at least half, and probably more, on the average, of the offspring, if the character is dominant. From 16 such matings, 21 polydactylous and 26 normal children are recorded. This is a slight bit of evidence for recessiveness. Two families are recorded (Figure 5: IV, 23; IV, 29) in which, although one parent was polydactylous, all of the children were normal (in one case 4, in the other, 6); further indications of recessivity.

Summing up the evidence for recessiveness, the character does not fulfill the requirements for dominance (must occur in every generation; must show up on the average in half or more of the offspring), while it does meet the criteria for recessiveness (must be homozygous when it appears, as evidenced by the result of mating two individuals showing the character; may skip one or more generations and appear when neither parent shows the character). There is no logical reason for supposing that the character is imperfectly dominant. It does not show any evidence of being sex-linked.

Blood group determinations were made on all the living individuals shown in the figures. This included in Figure 5 all of the individuals of generation VI, 46 of generation V, 22 of generation IV, 11 of generation III, and 1 of generation II. In Figure 7, blood group determinations were made on all individuals shown except 3 of generation II and 5 of generation I. In Figure 8, all individuals were grouped. The results throw some light on the linkage relations of the two sets of characters.

As already pointed out[6], certain crosses involving the blood groups and some other pair of characters will give definite evidence on the question of linkage in man. In this investigation, four families were found in which crossing over occurred between the blood groups and polydactylism. Five families occurred in which crossing over could have been detected, but apparently did not occur. Two of these families, however, contained but one child each. In the rest of the families, either the blood group of one of the parents was missing, or else the matings were such that no difference could have been detected betwen complete linkage and independent assortment or partial linkage even if crossing over had occurred.




**FOUR GENERATIONS OF POLYDACTYLISM**

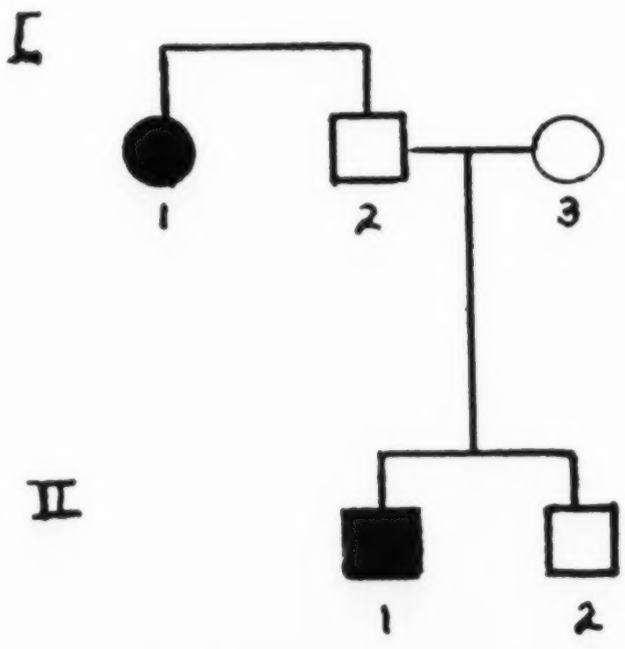
**Figure 7**

Recessive inheritance is indicated in this family and in the two generations shown in Figure 8.

The four families showing crossing over are as follows:

(1) The family of Moses Smith (Figure 5: VI, 1). The father and mother were both group B. Of the children, V, 1, 3, 4, 5, 6, and 7 were group B, while V, 2 and 8 were group O. In such a mating, a polydactylous child of group B could not occur in the same family with a polydactylous child of group O if there were complete linkage between the factors.

(2) The family of Barney Jones (Figure 5: IV, 16). The father was group AB, the mother A. Of the children, V, 16, 17 and 19 were group A, 15 and 20 were group B, and 18 was group AB. In such a mating, if




**RECESSIVE INHERITANCE INDICATED**

**Figure 8**

Two generations of polydactylism, with inheritance through normal "carriers."

complete linkage occurred, there could not be both polydactylous and normal children of group A in the same family.

(3) The family of James Ollison (Figure 5: IV, 23). The father was group A, the mother group B. This is the only blood group mating in which all four groups may be expected in the offspring, and this family is unique in that among the four children all four groups are represented. Of the children, V, 34 was group B, 35 group A, 36 group O, and 37 group AB. In such a mating, if complete linkage occurred, normal children of groups A and AB, or of O and B, could not occur in the same family.

(4) The family of Andrew O'Neal (Figure 5: IV, 33). The father was group O and the mother group B. Of the children, V, 47 and 48 were group B, while 49 and 50 were group O. In such a mating, if complete linkage occurred, there could not be both polydactylous and normal children of group B in the same family.

Complete linkage, therefore, does not occur between these factors, and in view of the relatively frequent occurrence of crossing over between polydactylism and the blood groups, it would seem that they are independently inherited.

## Literature Cited

1. Ballowitz, E. 1904. Ueber hyperdactyle Familien und die Vererbung der Vielfingerigkeit des Menschen. *Archiv. f. Rassen- und Gesellschafts-Biologie* I:347-365.

2. Castle, W. E. 1906. The origin of a polydactylous race of guinea-pigs. *Carnegie Inst. Wash. Publ.* 49:15-29.

3 Davenport, C. B. 1911. Heredity in relation to eugenics. New York, Henry Holt & Co., xii+298 pp.

4. Lucas, R. C. 1880. On a remarkable instance of hereditary tendency to the production of supernumerary digits. *Guy Hosp. Reports*, London, XXXV:417-419.

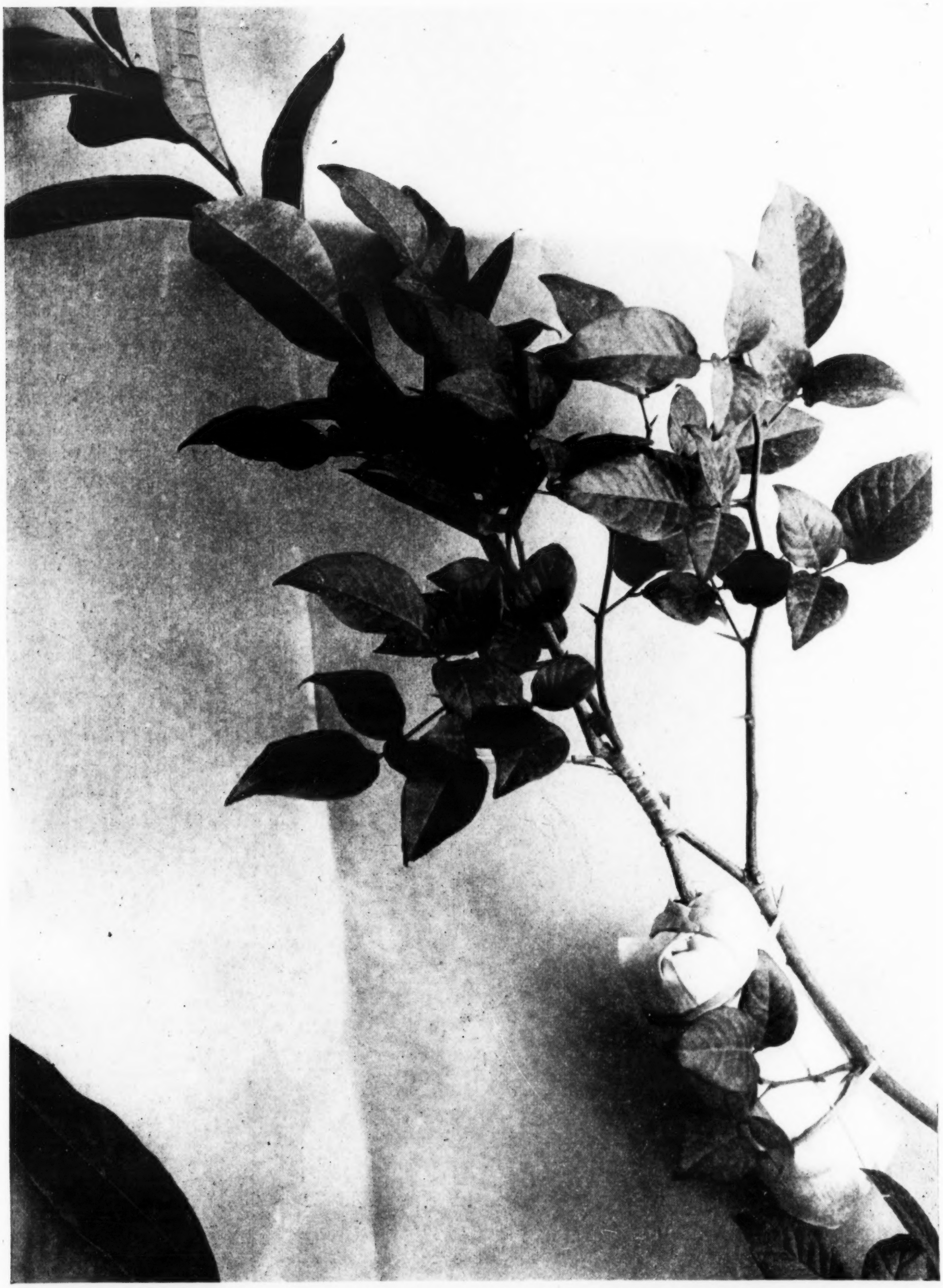
5. Milles, B. L. 1928. The inheritance of human skeletal anomalies. *Jour. Hered.*, XIX:28-46.

6. Snyder, L. H. 1926. Studies in human inheritance I. The linkage relations of the blood groups. *Zeitschr. f. Immunitatsforsch. und exper. Therapie*, XLIX:464-480.

---

## H. G. Wells on Eugenics

"It seems to me that to prevent the multiplication of people below a certain standard, and to encourage the multiplication of exceptionally superior people, is the only real and permanent way of the mending of the ills of the world."



**FIRST STAGE IN MAKING A NURSE-GRAFTED Y-CUTTING**

**Figure 9**

Forked branch of trifoliate-leafed *Balsamocitrus Dawei* with unifoliate *Aeglopsis Chevalieri* inarched as a nurse-plant on left fork, showing the nurse-plant with its roots wrapped in waxed paper container and tied fast to base of Y-shaped branch.

# THE NURSE-GRAFTED Y-CUTTING METHOD OF PLANT PROPAGATION

WALTER T. SWINGLE, T. RALPH ROBINSON, EUGENE MAY

*Office of Crop Physiology and Breeding, Bureau of Plant Industry, U. S. Department of Agriculture.*

THERE is need today for a scientific study of plant propagation in all its phases.

In Citrus, great progress has been made in propagating vegetatively not only all of the cultivated varieties of Citrus fruits, but also the numerous wild relatives of this genus that are coming every day more and more into prominence as stocks for special soils and climates, and to resist special diseases or insect pests.

This work has now been carried on for nearly two decades by the staff of the Office of Crop Physiology and Breeding, and it is proposed to publish the results obtained in a series of articles each complete in itself and each making, it is hoped, some essential contribution to the subject, outlined in sufficient detail to establish clearly the progress made in each particular problem.

During the past twenty years an effort has been made to bring together in the greenhouses of the Bureau of Plant Industry at Washington, D. C., and in California and Florida, a collection of living plants of all the species of Citrus and of as many as possible of the wild plants related to them—here interpreted to include all plants belonging to the sub-family Citrateae of the plant family Rutaceae. This collection now contains about ten or twelve species of the genus Citrus and about thirty species belonging to twenty other genera related to Citrus, and includes about one-half of the genera known in this group, but only about one-fifth of the species. Small as it is, it is, nevertheless, the largest single collection of plants of this group to be found in the world.

Every effort has been made to propagate all the species of all of the genera by vegetative means; particular attention has been given to this work because some of the species of Citrus and many of the species of the related genera were at first available only as small plants or seedlings that could not be made to fruit for many years, possibly never under greenhouse conditions. It was desired to test as many of these species as possible as rootstocks upon which to graft the commonly cultivated Citrus fruits such as oranges, lemons, limes, grapefruits, citrons, etc.

It was found years ago that several species of Citrus, many Citrus hybrids, and a number of the wild relatives of Citrus could be propagated readily from leafy cuttings, preferably terminal twigs of recent growth, no longer soft and tender nor yet fully hardened, provided such cuttings were placed in suitable soil with the leaves expanded in a moist chamber receiving diffused light. The rooting of such cuttings is greatly favored if bottom heat is supplied so that the soil is kept about 10° F. hotter than the air space above, and, at the same time, is kept well aerated from below. A small, inexpensive yet serviceable propagating bed of this character was described by the writers in a previous paper.[13] In such a propagating chamber, where high humidity is preserved by proper control of ventilation, the leafy cuttings do not wilt and are able to function normally, synthesizing starch and sugar and this reserve food material is carried to the base of the

cuttings doubtless stimulating the formation of roots and nourishing them as they grow. Often such cuttings start to form roots when but two weeks old and are well rooted in a month.

As soon as the roots of such cuttings are able to function well enough to supply water to the leaves above, the cuttings may be removed from the propagating frame and set out in the nursery row or in pots, preferably in a shaded greenhouse or lath shed to prevent excessive evaporation while the new plants are getting established and overcoming the inevitable shock of transplanting. It is possible to reduce this shock by starting the cuttings in paper or metal cylinders or prisms open at the bottom to facilitate aeration. The cuttings can then be transplanted in the containers with little or no shock when they are well rooted.

The sour orange, lemon and citron root freely, as do a number of Citrus relatives such as the box-leaved orange, *Severinia buxifolia* Ten.,* and the orange jessamine, *Chalcas paniculata L.* (*Murraya exotica L.*), but it was soon found that some species of Citrus and several of the wild relatives do not strike root from such cuttings or, at most, from only a very small per cent of them. Among the most refractory species of the Citrus group are the common sweet orange (*Citrus sinensis* Osb.), the Satsuma orange (*C. nobilis* Lour, var *unshiu* Swing.), and a number of Citrus relatives, especially *Balsamocitrus Dawei* Stapf. from Budonga Forest on the east side of Lake Albert Nyanza in the extreme western part of Uganda in east central Africa.

The *Balsamocitrus Dawei* appears to have a very restricted distribution and is known only from the original locality where it was collected by Mr. M. T. Dawe when he was Forest Conservator of Uganda in 1905. So far as is known, the only living plants under cultivation of this remarkable species, one of the largest of the Citrus relatives, are the few grown from seed collected in April, 1910, by the discoverer of the species during a trip to Budonga Forest and sent to the senior author in June, 1910. These plants are now in the greenhouses at Washington, D. C., and one plant is growing at the Citrus Experiment Station, Riverside, California. None of these have ever flowered or set fruit.

In spite of frequent attempts to root cuttings of this rare and interesting plant, only a very few struck root and grew. It was soon found possible, however, to graft Balsamocitrus on seedlings of *Aegtopsis Chevalieri* Swing, a related but much smaller tree from West Africa that fruits freely in the Washington greenhouses. This did not, however, supply what was chiefly desired—rooted plants of *Balsamocitrus Dawei* which could be tested as root stocks.

### Discovery of A New Method of Rooting Cuttings

Finally, in the Spring of 1926, the junior author hit upon a new method of propagation by the use of which not only was it possible to grow a good proportion of cuttings of *Balsamocitrus Dawei*, but also of choice varieties of the sweet orange, *Citrus sinensis* Osb., such as the Palestine variety, called Chamoudi, famous in Europe under the name of Jaffa orange (see Figure 14) and the Wase Satsuma of Japan, a form of the Mandarin orange (see Figure 13), *C. nobilis* Lour. var. *unshiu* Swing., a delicious, juicy, early ripening mutation of the Satsuma orange. Both of these had proved very difficult to grow from cuttings or air-layers.

This method has not yet failed for any Citrus plant on which it has been tested. It consists essentially in approach-grafting (inarching) a seedling

*Short descriptions, usually with illustrations, of *Severinia buxifolia, Balsamocitus Dawei,* and other Citrus relatives mentioned in this paper have been given by the senior author in Bailey, L. H., Cyclopedia of Horticulture, 6 vols., New York, 1914-1917.

plant (or a well-rooted cutting) to a Y-shaped leafy branch of the plant it is desired to propagate. (See Figure 9.) The little plant grafted to one arm of the forked branch (hereinafter referred to as the Y-cutting) is tied fast to the base of the crotch or Y which is left attached to the mother plant and not otherwise disturbed at first. To prevent the roots of the nurse-graft from drying out, they are packed in moist sphagnum moss and wrapped in waxed paper and watered when necessary—about once every ten days under greenhouse conditions.

When the nurse-graft begins to unite with the plant on which it is approach-grafted, usually after about two weeks, the base of the Y-shaped branch is "ringed" or girdled by removing an annulus of bark ⅛ to ¼ inch wide. This has the effect of causing an accumulation of the reserve food substances moving downward from the leaves and is well known to favor the formation of roots on the portion of the twig, in this case at the base of the Y-cutting, above the girdled zone. By the time the nurse-graft has become well united to one arm of the Y-cutting, usually after four to eight weeks from the time it was attached, the base of the Y-cutting has doubtless accumulated a certain stock of reserve plant food.

The Y-cutting is now cut from the mother plant at the point where it has been girdled a few weeks previously, and the cutting, together with the nurse-plant, is plunged into a suitable propagating chamber. See Figure 10. This should consist of a well-drained and well-aerated soil box, the soil bed being kept at a higher temperature than the air chamber above, which should be kept moderately cool and very moist, to prevent wilting of the leafy cutting. The roots of the nurse-graft should now be taken out of the waxed paper, freed from moss and carefully spread in the soil of the rooting bed. At the same time the top of the nurse-graft should be cut back to a few inches above the graft union with the side branch of the Y-cutting. If conditions of temperature and humidity are kept right, neither the Y-cutting nor the nurse-graft wilt, and soon roots will begin to form at the base of the Y-cutting.

After about three or four weeks, the branch of the Y-cutting to which the nurse plant is grafted is "nicked," i. e., partly cut off, below the graft union. See Figs. 10, 11, 12. Every few days the "nick" is made deeper, but the base of the grafted arm of the Y is not cut entirely off until the base of the Y-cutting has made good roots, usually about eight weeks after it has been plunged into the propagating bed.

When this cut is completed, the original Y-cutting is thereby divided into two independent plants; one consisting of the base and one arm of the Y growing as a rooted cutting, the other consisting of the tip of the other arm of the Y grafted on the nurse-plant.

In propagating the Wase Satsuma or other Citrus variety difficult to root from cuttings* it is possible to make use of both of these plants provided a nurse-plant has been used suitable as a stock for the variety propagated, as in the case of the Rusk citrange used as a nurse-plant for the Satsuma orange.

When only plants on their own roots are desired, as with *Balsamocitrus Dawei*, it is possible to root the tip of the branch of the original Y-cutting that has been grafted upon the nurse-plant. To do this, the grafted arm of the Y must be left long and the nurse-plant must not

*Some species of Citrus root freely from cuttings, especially the lemon and the citron; several others can be rooted if handled carefully, such as the common sour orange (*C. Aurantium L.*) and some hybrids such as citranges (produced by crossing the common sweet orange, *C. sinensis* Osb., and the trifoliate orange, *Poncirus trifoliata* Raf.). Others, like the sweet orange and the Satsuma are difficult to propagate from ordinary cuttings, no matter how carefully they are handled.

**Y-CUTTING AND NURSE-PLANT PLUNGED INTO SOIL**

**Figure 10**

Y-cutting of *Balsamocitrus Dawei* with one arm (on left) plunged in soil bed for rooting, the other arm (on right) grafted on *Aeglopsis Chevalieri*. The grafted arm of the cutting (right) is nearly cut through.

**NICKED ARM OF Y-CUTTING**

**Figure 11**

Rooted Y-cutting of *Balsamocitrus Dawei* to left with nurse-plant of *Aeglopsis Chevalieri* to right showing grafted arm nearly cut off just below union. (The plant was tied to a round stake while being photographed.)

be cut off too close above the graft union, but several inches above, far enough above to allow the tip of the scion (the grafted arm of the Y-cutting) to be bent in and approach-grafted to the tip of the nurse-plant. Then when this approach-graft begins to unite, the scion is girdled near its base, just above the union, and following the same course as with the original Y-cutting, the base of the scion is, after a month or so, cut off at the girdle and plunged with the nurse-graft in the propagating bed.

After the scion has rooted well, it can be cut off little by little from the nurse-plant and when finally it is cut free, the top as well as the bottom of the nurse-plant can be cut off, leaving only a short piece of the stock attached at the graft-union. By this supplementary graft, both arms of the original Y-cutting can be established on their own roots.

Naturally, the size of the Y-cutting will vary with the character of the plant being propagated. In case of Citrus and related genera, the base of the Y is usually 4-6 inches long; the two leafy side twigs 6-8 inches long, or even longer.

Although the nurse-grafted Y-cutting method of propagating has been in use less than two years, it has proved to be of very great utility not only in securing root stocks of rare species such as *Balsamocitrus Dawei,* of which seed is unobtainable, but also for such Citrus plants as the Wase Satsuma, that it is very desirable to grow on its own roots if possible.

In the case of the Wase Satsuma and other strains of the Satsuma orange usually grown near the northern limit of Citrus culture, in regions subject to occasional severe freezes, not only do they grow well on their own roots, but trees so grown have one very great advantage over ordinary grafted trees in that if frozen to the ground they do not need to be grafted again as they will sprout from the base of the stem or from the root and grow up directly into a tree of the variety planted without the need for the often difficult operation of re-budding or grafting the new sprouts—an operation that necessitates giving the whole plant a more or less severe shock at a time when the root system needs urgently all the food that can be manufactured in the leaves.

So far, most of the nurse-grafted Y-cuttings have been made in the greenhouse where temperature and humidity were controlled to some extent and severe wind was not a factor. It is confidently believed, however, that the method can be used out-of-doors if precaution is taken to attach the nurse-plant firmly to the tree to be propagated and to protect its roots from drying out, preferably by using a paraffin-coated marcottage box.* This marcottage box, designed to insure even moisture conditions without frequent attention to watering was invented by the junior author and Mr. Robert J. Bullen. Naturally, the method can be used only on plants that can be grafted, and especially plants having a cambium layer, particularly Gnetaceae (Ephedra, etc.), Coniferae, and the dicotyledonous Angiosperms.

The time required for rooting the Y-cutting may be shortened in many

*A marcottage box suitable for this purpose, small and convenient to apply and protecting the enclosed moss, coir or earth against drying out, has been protected for the use of the public by Government Patent No. 1,655,731, issued on January 10, 1928, to Eugene May and Robert J. Bullen. This box is essentially a paraffin-coated paper, fiber or metal box the lid and bottom parts of which telescope together. The two ends of the box are notched or slotted when being applied so as to permit the stem of the plant to be encircled closely, but without constriction, as to two sections are brought together. The box is filled with moss, coir or other suitable rooting material at the proper moisture content. The loss of moisture is so slight that such a box needs only infrequent attention, at intervals dependent somewhat on atmospheric conditions, see Fig. 13.

**ROOT DEVELOPMENT OF Y-CUTTING**

**Figure 12**

Same as Figure 11, showing extensive root system developed by the Y-cutting after growing one year in propagating bed. It has proved very difficult to root Balsamocitrus by any other method.

cases and rooting made more certain by applying a marcottage box or wrapping of moss inclosed in waxed cloth or paper to the base of the cutting (i. e., where it is "ringed" or girdled) at the time the girdling is done. See Fig. 13. In this way roots will be already in process of forming in many instances by the time it is safe for the cutting to be severed from the nurse graft. Even if the marcottage box does not force roots to start, no damage is done and callousing will usually be well advanced, hastening the later rooting of the cutting when it is placed in the soil bed.

### Modified Nurse-Grafted Y-Cutting Method Applicable to Single Plant by Branch Inarching

Whenever seedlings or rooted cuttings of allied species that can be grafted on the plant to be propagated, or when seedlings of the species to be propagated are available, the nurse-grafted Y-cutting method can be used.

In almost all cases one or the other of these alternative nurse-grafts can be used. In fact, only one case has yet come to light in the Crop Physiology and Breeding greenhouses, where no small plants suitable for nurse-grafting on the Y-cutting could be found. In this case recourse was had to self-inarching of two branches of the same plant, one of them forked and with the other branch grafted to one arm of the crotch. The base of the Y-shaped branch is later girdled and finally detached as if a nurse-plant had been attached to it instead of another branch of the same mother plant. The base of the detached branch is then plunged in a rooting chamber, the other branch remaining attached to the mother plant and being set into the rooting chamber through a small opening stopped with cotton to prevent loss of heat or humidity.

Recourse to this method has been necessary with a primitive wild pomegranate, *Punica protopunica* Balf., a very rare and interesting plant native of the island of Socotra, which does not graft readily with the cultivated pomegranate and has no other relatives, the genus Punica having only one other species, the ordinary pomegranate, *Punica Granatum* L. As the family Puniceae contains only the single genus Punica, there are probably no other plants in the world upon which this Socotran wild pomegranate could be grafted.

A modification of the nurse-grafted Y-cutting system of propagation can be used to advantage in propagating from very tall trees where Y-cuttings cannot be conveniently nurse-grafted in place. Such leafy Y-cuttings detached from the parent tree can be grafted with suitable stocks conveniently and easily in the propagating room, then plunged into a suitable propagating bed with controlled temperature and humidity. With some plants very difficult to root, this modification of the nurse-grafted Y-cutting system will doubtless fail but with many other plants it will probably succeed although the percentage of failure doubtless will be higher than with the use of the nurse graft on Y-cuttings still attached to the mother plant. However, the advantage of being able to put the cutting at once into a bed where temperature and humidity can be controlled offsets in part at least the disadvantage of severing the Y-cutting from the mother plant before it has become attached to the nurse graft and before it has accumulated a reserve of plant food at the base of the cutting where roots will form.

### Physiological Advantages of the Nurse-Grafted Y-Cuttings

A study of the processes that are necessary to form a rooted Y-cutting shows that at the critical stage when the cutting is severed from the mother plant and put in the propagating bed to root, the nurse-plant is able to supply the leaves of the cutting with

**NURSE-GRAFTED Y-CUTTING OF SATSUMA ORANGE**

**Figure 13**

Forked branch of Wase Satsuma orange to one arm of which nurse-plant of Rusk Citrange is attached for inarching. The root system of the nurse-plant (having trifoliate leaves) is enclosed in upper "marcottage box"; the base of the cutting to be rooted is enclosed at the point where girdled by the lower marcottage box.

water absorbed by the roots of the nurse-plant, and keep the cutting in good condition to carry on photosynthesis thereby creating sugar, starch and other carbohydrates, and doubtless also to synthesize the nitrogenous organic compounds essential as food to be used in the formation of new roots at the base of the cutting. To do this it is true that the water absorbed by the roots of the nurse plant must move over a zig-zag or N-shaped course to reach the ungrafted arm of the Y-shaped branch. Our experiments with these inarched cuttings indicate that water is thus supplied to both arms of the Y-branch. That water will move freely through wood in the reverse of the usual direction was proved by Hales more than two centuries ago.[9]

The superiority of the nurse-grafted Y-cutting in comparison with other methods of vegetative propagation is doubtless due to the fact that it is thus continuously supplied with nitrogenous and other essential mineral plant foods (especially phosphorus and potash) absorbed from the soil water and is able continuously to synthesize not only carbohydrates from water and carbon-dioxide but also the complex nitrogenous organic compounds essential to form protoplasm. As long as the cutting is attached to the mother plant, even after it has been girdled, it is supplied abundantly with water absorbed by the roots from the soil. When the Y-cutting is removed from the mother plant the root of the nurse plant placed in moist soil then serves to absorb both inorganic nitrogen and other essential mineral salts necessary for the synthesis of proteins.

With plants difficult to root this is doubtless a matter of prime importance since the cutting is in a very critical stage of its development when it must create a system of functionally active roots adequate to supply the leafy top of the cutting with all the water and mineral elements it needs.

The various forms of elaborated plant food synthesized in the leaves are carried down toward the roots by the living cells of the inner bark; the transfer of such food is arrested by removing a ring of bark at the base of the Y-cutting which leads to a local accumulation of elaborated plant food.

The cutting, after it has been removed from the mother plant and set in the propagating bed, doubtless continues to send much of the plant food synthesized in the leaves straight down the stem to the base where roots are forming rather than over the N-shaped course necessary to take the food down to the root of the nurse-plant. Not only is this a longer route to travel but it involves the *transport of elaborated plant food up one arm of the original Y-cutting in the reverse direction to that usually taken by the products of photosynthesis.*

There is evidence to show that the transport of elaborated plant food in twigs is usually if not always toward the root end of the twig and not in the reverse direction. For example, Vochting[17] removed a ring of bark from the middle of a cutting of a willow, *Salix viminalis*, hung the twig upside down and put a short glass tube around the girdled region and filled the tube with water held in place by a split rubber cork at the lower end of the glass tube. This experiment showed that in spite of the inverted position of the cutting, roots developed luxuriantly in the water at the root end of the morphologically upper half of the cutting and none were formed at the morphologically upper end of the base of the cutting in spite of the fact that this end was also in water and hence favorably situated for root production. The girdling in effect cut the single twig into two cuttings; the one having its basal end in water developed abundant roots; the other, with its basal end in the air, showed traces of root at its base, but none at its apex under water. Vochting gives many other proofs for the very definite

polarization of stems, twigs and roots of plants.

Jost[10] reports that "if from an unbranched stem we remove a ring of cortex right into the wood, the part of the tree situated below the region of ringing is not filled with starch, whilst the part above the ringing accumulates it abundantly. If a narrow bridge of cortex be retained, connecting the upper with the lower part of the twig, the sugar flows backward, toward the roots, but spreads laterally very slowly. If the bridge be in the form of a step ( ⌊—⌋ ), [two vertical strips, one from above and one from below, connected by a horizontal strip] no backward passage of the products of assimilation takes place, since the horizontal part of the bridge does not conduct them."

In the light of the above experiments and those made by many other physiologists, it appears that there is in the nurse-graft Y-cutting a *veritable trap-action* by virtue of which the ungrafted arm of the Y-cutting is freely and continuously supplied with water absorbed by the roots first of the parent plant and later of the nurse plant and thereby placed in position to synthesize freely the carbohydrate necessary for supporting the growth of roots at the base of the Y-cutting, and that such elaborated food stuffs are in large part, if not wholly, translocated directly to the base of the cutting and not over the zigzag route leading to the nurse-graft root which latter route would involve the transport of such elaborated food through the phloem elements of the bark of one arm of the Y-cutting in the direction from root to top, the reverse of the normal course of the transportation of elaborated food stuffs.

There is furthermore every reason to believe that up to the time when the Y-cutting is severed a considerable part of the elaborated food material of the grafted arm as well travels downward over that portion of the cortex not disturbed in grafting to the base of the Y-cutting, thus affording a double source of nourishment.

This may prove to be very important, since the grafted arm of the cutting is in direct connection with the functioning root system of the nurse-plant which is able to supply it with both water and inorganic nitrogenous salts, thereby permitting the synthesis of both carbohydrates and nitrogenous food materials, part of which is undoubtedly translocated to the base of the Y-cutting and there used to nourish the newly forming roots.

## Previous Work in Inarching and Nurse-Grafting

The inarching or approach grafting of plants doubtless dates from remote antiquity. It seems to have been known to Pliny according to Thouin.[16]

Grafting by approach was described and figured by Bussato[6] more than three centuries ago, but his description of the process shows that the bark and inner bark were cut away on two sides of a twig which is then inserted in a cut on split branch of a nearby plant.

Duhamel de Monceau and Baltet[4] both describe approach grafting but none of these writers make any use of such approach grafting for rooting cuttings.

Oliver[13] described and figured a method of approach grafting by using young seedling plants with the roots in soil surrounded with coir and tied up in cloth. Such seedlings inarched into twigs of another plant were left attached until the graft was thoroughly healed on, then the scion was "nicked" below the union and gradually cut off, leaving a scion grafted on the seedling root which was then planted and grew. He called this method the seedling-inarch method of propagation. He noticed that the mangosteen so propagated on roots of *Platonia insignis* often struck roots from the base of the mangosteen scion and sometimes the stock rotted away, leaving the mangosteen growing on

its own roots. He did not propose to secure rooted mangosteen cuttings in this way, but worked out what he called the nurse-plant method of propagation wherein mangosteen seedlings were inarched on Platonia seedlings and when the graft was well healed the top of the Platonia plant was cut off, leaving the mangosteen growing on its own roots and also grafted on a root of the Platonia. This nurse plant method was used because the mangosteen grows poorly on its own roots and seems to be given much more vigor by the roots of Platonia and thereby enabled to grow later on its own roots.*

The aim of the various methods of inarching noted above is obviously to secure grafted plants, not rooted cuttings, although by the so-called nurse-plant method Oliver did get in some cases mangosteens growing on their own roots. In the latter case however, no forked or Y-shaped scions were used. There was no thought of getting both a rooted cutting and a grafted plant by one operation, nor was there secured the still more important trap action of the nurse-grafted Y-cutting. A cutting-grafting method is described by Bailey[2] as follows: "Cuttings of plants which root with difficulty are sometimes grafted upon those which root easily. . . . When the plants are transplanted the following autumn or spring, the nurse or stock can be removed, the scion having taken root."

Shaw[17] and Auchter[1] have secured apple cuttings on their own roots by using this method.[17]

Chandler[8] further modified this method, using a piece of root as a side graft on the apple scion, leaving a stub of the scion extending a few inches below the graft union. Root formation at the end of this scion stub was many times more abundant than that obtained on scions grafted at the base.

The so-called "bottle grafting" is done by allowing the lower end of a scion to rest in a bottle of water which may be tied to a tree and permits top grafting of species hard to graft by ordinary methods. This method, said to have been discovered by William Pike, was described and figured by John Carr[17] in 1827, and also by Lindley[11] and more recently by Blakeslee and Farnham.[5] It has been seen in use in Florida by one of the writers in top grafting the avocado, *Persea gratissima* Pax. This method again yields a grafted plant, not a rooted cutting.

The layering of plants results in securing a rooted cutting, usually by bending down a branch of the mother plant and covering it with soil kept moist until roots are formed. Often the layer is cut partly through when it is covered and sometimes a ring of bark is removed. The removal of a ring of bark to facilitate the rooting of layers dates back at least as far as Malpighi[12] who lived in the seventeenth century.

Air-layering or marcottage, is merely the application of similar methods to upright branches that cannot safely or conveniently be bent down to the ground. Bailey[7] discusses this method at some length and says: "Pot-layering, air-layering and Chinese layering

*This method was used by Mr. H. H. Boyle (for a number of years in charge of the Citrus greenhouses of the Office of Crop Physiology and Breeding Investigations) in saving the seedling hybrids of Poncirus and Fortunella made by the senior author in 1909, when it was found that most of these seedlings died soon after germinating. They were inarched on vigorous stocks and many were saved in this way that rotted off at the surface of the ground shortly after being inarched. With vigorous hybrids, Mr. Boyle was able to force rapid development of the top of the seedling grafted in an older stock as Mr. Oliver had done with a hybrid of the Australian finger lime (*Microcitrus australasica*) and the Calamondin (*Citrus mitis*). (*l. c.* p. 10, pl. 1.) *He was also able in some cases to save the root of the seedling hybrid and the part of the stem below the graft which sent out side buds and grew vigorously.* In this way the original hybrid plant was saved and yet the earliest possible graft was made from it to be forced as soon as possible into flowering and fruiting.

**PROPAGATION OF CHAMOUDI ORANGE**

**Figure 14**

Tip of branch of Chamoudi orange showing three terminal twigs to one of which a nurse graft of Ichang lemon is attached. The cutting has been in the propagating bed for some weeks and has already developed a small root system. The grafted branch has been "nicked" but not yet fully detached below the union with the nurse-plant.

are terms applied to the rooting of rigid stems by means of surrounding them while in their natural position with earth or moss or similar material. The stem is wounded—commonly girdled—and a divided pot or box is placed about it and filled with earth. The roots start from above the girdle, and when they have filled the pot the stem is severed, headed back, and planted." P. J. Wester[20] calls this method by the French name of marcottage, commonly used in tropical countries. It is a very good method whenever it can be used, but fails or gives very poor results in case of many plants hard to root such as *Balsamocitrus Dawei,* Satsuma orange, common sweet orange, and many other tropical and subtropical economic plants.

### The Valencian Nurse-Graft Cutting Method

A method of rooting cuttings used in the Province of Valencia, Spain, to propagate the orange, has some analogy with the Y-cutting. This method was studied in Valencia by Dr. L. Trabut, the Government Botanist of Algeria, who described it to the senior author in 1911. A small scion of citron is grafted into the twig of the orange to be propagated and the scion is protected from drying out by being inclosed with waxed paper which is tied to the orange twig above and below the citron scion. When the scion has made a good union with the orange twig the whole twig with the citron graft attached is cut off and planted as a cutting. The citron soon strikes root, as it roots very easily, and after the cutting so rooted has been planted out for about a year the base of the orange twig will be found to have made roots of its own, whereupon the citron graft with its roots is cut away, leaving the orange cutting growing on its own roots.

### Discussion

None of these systems combine all the advantages of the nurse-grafted Y-cutting method and in case of species difficult to root, such as the *Balsamocitrus Dawei,* and the Satsuma orange, even the most careful marcottage or air-layering of a girdled branch carried out in a moist, well-heated greenhouse rarely succeeds whereas the nurse-grafted Y-cuttings strike roots readily.

Rooted cuttings are very desirable in many cases since both stock and scion can in this way be propagated without any genetic variation, whereas propagation by grafting superior races of tree crop plants on seedling stocks is subject to uncertainty arising from the variability of the root. Dr. H. J. Webber, Director of the Citrus Experiment Station of the University of California at Riverside, California, has found[18] that a most astonishing amount of variation is shown by seedling sour oranges (*Citrus Aurantium* L.) the stock commonly used in California and Arizona for the ordinarily cultivated Citrus fruits—oranges, lemons and grapefruit. Not only did he find this stock variable, but buds known to be uniform in character inserted on the more aberrant sour orange stocks produced trees differing widely in growth and fruitfulness.

There is good reason to believe that many tropical tree crops are now grown at unjustifiably high cost because of the highly variable nature of the seedlings used for propagating these crops, or because of the equally great or even greater variability of the seedling stocks used when such tree crops are propagated by grafting. The nurse-grafted Y-cutting method is likely to be found useful in many parts of the world as attention becomes directed more and more to securing improved varieties of cultivated trees having a high performance record and uniform stocks on which to graft them.

### Summary

For the past two decades extensive efforts have been made, using both old and new methods, to propagate

all species of Citrus fruit trees and their wild relatives in order to obtain rooted cuttings. In most cases these efforts were successful.

Several new methods have been worked out and published, such as Oliver's seedling-inarch method of grafting, described by him in 1911, and the solar propagating frame for rooting cuttings, described by the writers in 1924.

However, some few refractory species of Citrus plants, such as the Satsuma orange and *Balsamocitrus Dawei,* could not be propagated so as to secure a good percentage of rooted cuttings by any known method of vegetative propagation.

A new method of rooting cuttings was discovered not quite two years ago which gave good results with these and other Citrus trees hard to root. It is called the nurse-grafted Y-cutting method and is simple and easy to use, giving excellent results.

This new method seems to show physiological advantages over any previously used method of rooting cuttings or of air-layering (marcottage) having apparently a *trap action* by virtue of which the soil solution absorbed by the roots of the nurse plant supplies the leaves of the Y-cutting with water mineral food but the elaborated plant food made in the ungrafted arm (and part of that made in the grafted arm) of the Y-cutting flows to the base of the Y-cutting where it nourishes the developing roots and not to the root of the nurse plant.

It is believed that this new method is likely to prove of great value in propagating superior individuals of many plants that have not yet been propagated successfully except by grafting on seedling stocks.

Such seedling stocks usually show great variability and much more uniform stocks can be secured in most instances by using this new method.

Many cultivated trees grow very well on their own roots and such trees propagated by cuttings taken from individual trees having a high performance record usually exhibit no genetic variation either in tops or roots, and hence represent the highest possible uniformity, that is rivaled or possibly equaled only by scions from selected trees grafted on vegetatively propagated stocks taken from a single individual plant.

In some regions it is advantageous to have fruit trees propagated on their own roots, since such trees if frozen to the ground by severe cold weather will spring up again from the base of the trunk or from the roots without the necessity of grafting the sprouts. This applies especially to the Satsuma orange which is largely grown in regions subject to occasional severe freezes.

## Literature Cited


1. Auchter, E. C. An experiment in propagating apple trees on their own roots, *Proc. Am. Soc. Hort. Sc. 22*:205-211, 1925.
2. Bailey, L. H. The Nursery Manual. New York, 1920, pp. 76-79, figs, 67-75.
3. Bailey, L. H. The Nursery Book, 16th ed. New York, 1911. pp. 110-112 and 131-132, fig. 105.
4. Baltet, Charles. L'art de greffer. 12 mo. Paris, 5th ed. 1892. (Later editions and an English translation are available of this work.)
5. Blakeslee, Albert F. and Farnham, M. E. Bottle Grafting, *Journ. of Heredity*. 14:171-173 (July, 1923).
6. Bussato, Marco. Giardino di agricoltura. 4° 8+74+6 pp. Venice, 1599.
7. Carr, John. On an improvement in the Propagation of the Double Camelia, *Gardener's Magazine*, *2*:33, with figures. London, 1827.
8. Chandler, W. H. Polarity in the formation of scion roots. *Proc. Amer. Soc. Hort. Sci. 22*:218-222, 1905.
9. Hales, Stephen. Vegetable Staticks 8°, London, 1727, Experiment 26, pp. 87-89. Plate 6, fig. 13.
10. Jost, Ludwig. Lectures on Plant Physiology, translation by R. J. Harvey Gibson, Oxford, 1907, p. 171.
11. Lindley, John. The Theory of Horticulture. Second American Edition, with notes, etc., by H. J. Downing. New York, 1852, p. 239, fig. 30.

12. Malpighi, Marcell. Opera Omnia, London, 1686, p. 35.

13. Oliver, George W. The Seedling-Inarch and Nurse-Plant Methods of Propagation. *Bureau of Plant Industry Bul.* 201, 8°, 43 pp. 9 pls. Washington, D. C., Government Printing Office, 1911.

14. Shaw, J. K. The propagation of apple trees on their own roots, *Mass. Agr. Exp. Sta. Bul.* 190, 1919.

15. Swingle, Walter T., Robinson, T. Ralph, and May, Eugene, Jr. The Solar Propagating Frame for Rooting Citrus and Other Subtropical Plants. *U. S. Dept. Agr. Circular* 310, Washington, D. C., Government Printing Office, May, 1924, 8°, 14 pp., 6 text cut.

16. Thouin, A. Description de l'école d'agriculture pratique du Museum d'histoire naturelles. 6me Memoire, Des examples de toutes sortes de greffes exposees dans cette Ecole. *Annals du Museum d'histoire Naturelle*, 16:209-239, Paris, 1910. See p. 222.

17. Vochting, Herman. Ueber Organbildung im Pflanzenreich, Pt. 1, pp. 131-132, Pl. I, fig. 8, Bonn., 1878.

18. Webber, Herbert John. Selection of Stocks in Citrus Propagation, *California Agric. Exp. Station Bulletin* 317, pp. 267-301, Berkeley, 1920.

19. Wester, P. J. Plant Propagation in the Tropics. *Bureau of Agriculture Bulletin No.* 32, Manila, 1916, pp. 27, fig. 24.

## Books Received

*BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the* Journal *will be reviewed in later numbers.*

The Nature of the Physical World: By A. S. Eddington. "This book contains the text of Prof. Eddington's Gifford lectures, delivered in 1927. They contain an exposition of modern scientific progress and discuss the relation of the physical world to wider aspects of knowledge, including the mind." Pp. 353. 15 chapters. Price, $3.75. New York, The Macmillan Company, 1928.

Handbook of Microscopical Technique, For workers in Both Animal and Plant Tissues: Edited by C. E. McClung, Ph. D.; 24 Contributing Authors. Pp. 495. 11 chapters, 43 illustrations. Price, $8.00. New York, Paul B. Hoeber, Inc., 1929.

The Cytology of Oenothera: By R. Ruggles Gates. Pp. 91. 12 chapters. Reprint from Bibliographia Genetica IV, 1928. Gravesend, Netherlands.

The Characters of the Human Skin in Their Relations to Questions of Race and Health: By H. J. Fleure. Pp. 32. Price, 85c. New York, Oxford University Press, American Branch, 1927.

Report of the United States National Museum. Report on the Progress and Condition of the United States National Museum for the year ended June 30, 1928. Contains a Foreword by Alexander Wetmore, Asst. Secretary, Smithsonian Institution, reports of Operations during the year, Detailed reports on the collections, by members of the Staff of the Museum, and lists of Accessions, Publications, etc. Pp. 216. Price 25c. Washington, D. C., United States Government Printing Office, 1928.

Racial Hygiene: A Practical Discussion of Eugenics and Race Culture, by Thurman B. Rice, A. M., M. D. Pp. 376. 25 chapters. Price, $4.50. New York, The Macmillan Company, 1929.

## MEMBERSHIP BLANK

The American Genetic Association, Victor Building, Washington, D. C.

Gentlemen: I ☐ enclose ☐ will remit $3.00 for membership for one year. This entitles me to receive the Journal of Heredity each month and all other privileges of membership without any further obligation on my part.

*Name* .....

*Street and Number* .....

*City and State* .....

*Nominated by* .....

*Member A. G. A.*